

TGD UNIVERSE AS A CONSCIOUS HOLOGRAM

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0.1 PREFACE

Brief summary of TGD

Towards the end of the year 2023 I became convinced that it would be appropriate to prepare collections about books related to TGD and its applications. The finiteness of human lifetime was my first motivation. My second motivation was the deep conviction that TGD will mean a revolution of the scientific world view and I must do my best to make it easier.

The first collection would relate to the TGD proper and its applications to physics. Second collection would relate to TGD inspired theory of consciousness and the third collection to TGD based quantum biology. The books in these collections would focus on much more precise topics than the earlier books and would be shorter. This would make it much easier for the reader to understand what TGD is, when the time is finally mature for the TGD to be taken seriously. This particular book belongs to a collection of books about TGD proper.

The basic ideas of TGD

TGD can be regarded as a unified theory of fundamental interactions but is not the kind of unified theory as so called GUTs constructed by graduate students in the seventies and eighties using detailed recipes for how to reduce everything to group theory. Nowadays this activity has been completely computerized and it probably takes only a few hours to print out the predictions of this kind of unified theory as an article in the desired format. TGD is something different and I am not ashamed to confess that I have devoted the last 45 years of my life to this enterprise and am still unable to write The Rules.

If I remember correctly, I got the basic idea of Topological Geometrophysics (TGD) during autumn 1977, perhaps it was October. What I realized was that the representability of physical space-times as 4-dimensional surfaces of some higher-dimensional space-time obtained by replacing the points of Minkowski space with some very small compact internal space could resolve the conceptual difficulties of general relativity related to the definition of the notion of energy. This belief was too optimistic and only with the advent of what I call zero energy ontology the understanding of the notion of Poincare invariance has become satisfactory. This required also the understanding of the relationship to General Relativity.

It soon became clear that the approach leads to a generalization of the notion of space-time with particles being represented by space-time surfaces with finite size so that TGD could be also seen as a generalization of the string model. Much later it became clear that this generalization is consistent with conformal invariance only if space-time is 4-dimensional and the Minkowski space factor of the embedding space is 4-dimensional. During last year it became clear that 4-D Minkowski space and 4-D complex projective space CP_2 are completely unique in the sense that they allow twistor space with Kähler structure.

It took some time to discover that also the geometrization of also gauge interactions and elementary particle quantum numbers could be possible in this framework: it took two years to find the unique internal space (CP_2) providing this geometrization involving also the realization that family replication phenomenon for fermions has a natural topological explanation in TGD framework and that the symmetries of the standard model symmetries are much more profound than pragmatic TOE builders have believed them to be. If TGD is correct, the mainstream particle physics chose the wrong track leading to the recent deep crisis when people decided that quarks and leptons belong to the same multiplet of the gauge group implying instability of the proton.

Instead of trying to describe in detail the path, which led to TGD as it is now with all its side tracks, it is better to summarize the recent view which of course need not be final.

TGD can be said to be a fusion of special and general relativities. The Relativity Principle (Poincare Invariance) of Special Relativity is combined with the General Coordinate Invariance and Equivalence Principle of General Relativity. TGD involves 3 views of physics: physics geometry, physics as number theory and physics as topological physics in some sense.

Physics as geometry

"Geometro-" in TGD refers to the idea about the geometrization of physics. The geometrization program of Einstein is extended to gauge fields allowing realization in terms of the geometry of surfaces so that Einsteinian space-time as abstract Riemann geometry is replaced with sub-manifold geometry. The basic motivation is the loss of classical conservation laws in General Relativity Theory (GRT)(see **Fig. 12**). Also the interpretation as a generalization of string models by replacing string with 3-D surface is natural.

- Standard model symmetries uniquely fix the choice of 8-D space in which space-time surfaces live to $H = M^4 \times CP_2$ [L157]. Also the notion of twistor is geometrized in terms of surface geometry and the existence of twistor lift fixes the choice of H completely so that TGD is unique [L57, L79](see **Fig. 13**). The geometrization applies even to the quantum theory itself and the space of space-time surfaces - "world of classical worlds" (WCW) - becomes the basic object endowed with Kähler geometry (see **Fig. 14**). The mere mathematical existence of WCW geometry requires that it has maximal isometries, which together twistor lift and number theoretic vision fixes it uniquely [L159].
- General Coordinate Invariance (GCI) for space-time surfaces has dramatic implications. A given 3-surface fixes the space-time surface almost completely as analog of Bohr orbit (preferred extremal). This implies holography and leads to zero energy ontology (ZEO) in which quantum states are superpositions of space-time surfaces [K146, L89].
- From the beginning it was clear that the theory predicts the presence of long ranged classical electro-weak and color gauge fields and that these fields necessarily accompany classical electromagnetic fields in all scales. It took about 26 years to gain the maturity to admit the obvious: these fields are classical correlates for long range color and weak interactions assignable to the phases of ordinary matter predicted by the number theoretic vision and behaving like dark matter but identifiable as matter explaining the missing baryon problem whereas the galactic dark matter would correspond to the dark energy assignable monopole flux tubes as deformations of cosmic strings. The only possible conclusion is that TGD physics is a fractal consisting of an entire hierarchy of fractal copies of standard model physics. Also the understanding of electro-weak massivation and screening of weak charges has been a long standing problem and p-adic physics solved this problem in terms of p-adic thermodynamics [K29, K69] [L143].
- One of the most recent discoveries of classical TGD is exact general solution of the field equations. Holography can be realized as a generalized holomorphy realized in terms of what I call Hamilton-Jacobi structure [L149]. Space-time surfaces correspond to holomorphic imbeddings of the space-time surface to H with a generalized complex structure defined by the vanishing of 2 analytic functions of 4 generalized complex coordinates of H . These surfaces are automatically minimal surfaces. This is true for any general coordinate invariant action constructed in terms of the induced geometric structures so that the dynamics is universal. Different actions differ only in the sense that singularities at which the minimal surface property fails depend on the action. This affects the scattering amplitudes, which can be constructed in terms of the data related to the singularities [L166].
- Generalized conformal symmetries define an extension of conformal symmetries and one can assign to them Noether charges. Besides this the so called super-symplectic symmetries associated with $\delta M_+^4 \times CP_2$ define isometries of the "world of classical worlds" (WCW), which by holography is essentially the space of Bohr orbits of 3-surfaces as particles so that quantum TGD is expected to reduce to a generalization of wave mechanics.

Physics as number theory

During these years TGD led to a rather profound generalization of the space-time concept. Quite general properties of the theory led to the notion of many-sheeted space-time with sheets representing physical subsystems of various sizes. At the beginning of 90s I became dimly aware of the

importance of p-adic number fields and soon ended up with the idea that p-adic thermodynamics for a conformally invariant system allows to understand elementary particle massivation with amazingly few input assumptions. The attempts to understand p-adicity from basic principles led gradually to the vision about physics as a generalized number theory as an approach complementary to the physics as an infinite-dimensional spinor geometry of WCW approach. One of its elements was a generalization of the number concept obtained by fusing real numbers and various p-adic numbers along common rationals. The number theoretic trinity involves besides p-adic number fields also quaternions and octonions and the notion of infinite prime.

Adelic physics [L55, L56] fusing real and various p-adic physics is part of the number theoretic vision, which provides a kind of dual description for the description based on space-time geometry and the geometry of "world of classical words". Adelic physics predicts two fractal length scale hierarchies: p-adic length scale hierarchy and the hierarchy of dark length scales labelled by $h_{eff} = nh_0$, where n is the dimension of extension of rational. The interpretation of the latter hierarchy is as phases of ordinary matter behaving like dark matter. Quantum coherence is possible in arbitrarily long scales. These two hierarchies are closely related. p-Adic primes correspond to ramified primes for a polynomial, whose roots define the extension of rationals: for a given extension this polynomial is not unique.

$M^8 - H$ duality

The concrete realization of the number theoretic vision is based on $M^8 - H$ duality (see **Fig. 15**). What the precise form is this duality is, has been far from clear but the recent form is the simplest one and corresponds to the original view [L161]. M^8 corresponds to octonions O but with the number theoretic metric defined by $Re(o^2)$ rather than the standard norm and giving Minkowskian signature.

The physics in M^8 can be said to be algebraic whereas in H field equations are partial differential equations. The dark matter hierarchy corresponds to a hierarchy of algebraic extensions of rationals inducing that for adeles and has interpretation as an evolutionary hierarchy (see **Fig. 16**). p-Adic physics is an essential part of number theoretic vision and the space-time surfaces are such that at least their M^8 counterparts exists also in p-adic sense. This requires that the analytic function defining the space-time surfaces are polynomials with rational coefficients.

$M^8 - H$ duality relates two complementary visions about physics (see **Fig. 17**), and can be seen as a generalization of the momentum-position duality of wave mechanics, which fails to generalize to quantum field theories (QFTs). $M^8 - H$ duality applies to particles which are 3-surfaces instead of point-like particles.

p-Adic physics

The idea about p-adic physics as physics of cognition and intentionality emerged also rather naturally and implies perhaps the most dramatic generalization of the space-time concept in which most points of p-adic space-time sheets are infinite in real sense and the projection to the real imbedding space consists of discrete set of points. One of the most fascinating outcomes was the observation that the entropy based on p-adic norm can be negative. This observation led to the vision that life can be regarded as something in the intersection of real and p-adic worlds. Negentropic entanglement has interpretation as a correlate for various positively colored aspects of conscious experience and means also the possibility of strongly correlated states stable under state function reduction and different from the conventional bound states and perhaps playing key role in the energy metabolism of living matter.

If one requires consistency of Negentropy Maximization Principle with standard measurement theory, negentropic entanglement defined in terms of number theoretic negentropy is necessarily associated with a density matrix proportional to unit matrix and is maximal and is characterized by the dimension n of the unit matrix. Negentropy is positive and maximal for a p-adic unique prime dividing n .

Hierarchy of Planck constants labelling phases ordinary matter dark matter behaving like dark matter

One of the latest threads in the evolution of ideas is not more than nine years old. Learning about the paper of Laurent Nottale about the possibility to identify planetary orbits as Bohr orbits with a gigantic value of gravitational Planck constant made once again possible to see the obvious. Dynamical quantized Planck constant is strongly suggested by quantum classical correspondence and the fact that space-time sheets identifiable as quantum coherence regions can have arbitrarily large sizes. Second motivation for the hierarchy of Planck constants comes from bio-electromagnetism suggesting that in living systems Planck constant could have large values making macroscopic quantum coherence possible. The interpretation of dark matter as a hierarchy of phases of ordinary matter characterized by the value of Planck constant is very natural.

During summer 2010 several new insights about the mathematical structure and interpretation of TGD emerged. One of these insights was the realization that the postulated hierarchy of Planck constants might follow from the basic structure of quantum TGD. The point is that due to the extreme non-linearity of the classical action principle the correspondence between canonical momentum densities and time derivatives of the imbedding space coordinates is one-to-many and the natural description of the situation is in terms of local singular covering spaces of the imbedding space. One could speak about effective value of Planck constant $\hbar_{eff} = n \times \hbar$ coming as a multiple of minimal value of Planck constant. Quite recently it became clear that the non-determinism of Kähler action is indeed the fundamental justification for the hierarchy: the integer n can be also interpreted as the integer characterizing the dimension of unit matrix characterizing negentropic entanglement made possible by the many-sheeted character of the space-time surface.

Due to conformal invariance acting as gauge symmetry the n degenerate space-time sheets must be replaced with conformal equivalence classes of space-time sheets and conformal transformations correspond to quantum critical deformations leaving the ends of space-time surfaces invariant. Conformal invariance would be broken: only the sub-algebra for which conformal weights are divisible by n act as gauge symmetries. Thus deep connections between conformal invariance related to quantum criticality, hierarchy of Planck constants, negentropic entanglement, effective p-adic topology, and non-determinism of Kähler action perhaps reflecting p-adic non-determinism emerges.

The implications of the hierarchy of Planck constants are extremely far reaching so that the significance of the reduction of this hierarchy to the basic mathematical structure distinguishing between TGD and competing theories cannot be under-estimated.

TGD as an analog of topological QFT

Consider next the attribute "Topological". In condensed matter physical topological physics has become a standard topic. Typically one has fields having values in compact spaces, which are topologically non-trivial. In the TGD framework space-time topology itself is non-trivial as also the topology of $H = M^4 \times CP_2$. Since induced metric is involved with TGD, it is too much to say that TGD is topological QFT but one can for instance say, that space-time surfaces as preferred extremals define representatives for 4-D homological equivalence classes.

The space-time as 4-surface $X^4 \subset H$ has a non-trivial topology in all scales and this together with the notion of many-sheeted space-time brings in something completely new. Topologically trivial Einsteinian space-time emerges only at the QFT limit in which all information about topology is lost (see **Fig. 18**).

Any GCI action satisfying holography=holomorphy principle has the same universal basic extremals: CP_2 type extremals serving basic building bricks of elementary particles, cosmic strings and their thickenings to flux tubes defining a fractal hierarchy of structure extending from CP_2 scale to cosmic scales, and massless extremals (MEs) define space-time correletes for massless particles. World as a set of particles is replaced with a network having particles as nodes and flux tubes as bonds between them serving as correlates of quantum entanglement.

"Topological" could refer also to p-adic number fields obeying p-adic local topology differing radically from the real topology (see **Fig. 19**).

Zero energy ontology

TGD inspired theory of consciousness entered the scheme after 1995 as I started to write a book about consciousness. Gradually it became difficult to say where physics ends and consciousness theory begins since consciousness theory could be seen as a generalization of quantum measurement theory by identifying quantum jump as a moment of consciousness and by replacing the observer with the notion of self identified as a system which is conscious as long as it can avoid entanglement with environment. The somewhat cryptic statement “Everything is conscious and consciousness can be only lost” summarizes the basic philosophy neatly.

General coordinate invariance leads to the identification of space-time surfaces are analogous to Bohr orbits inside causal diamond (CD). CD obtained as intersection of future and past directed light-cones (with CP_2 factor included). By the already described hologamphy, 3-dimensional data replaces the boundary conditions at single 3-surface involving also normal derivatives with conditions involving no derivatives.

In zero energy ontology (ZEO), the superpositions of space-time surfaces inside causal diamond (CD) having their ends at the opposite light-like boundaries of CD, define quantum states. CDs form a scale hierarchy (see **Fig. 20** and **Fig. 21**). Quantum states are modes of WCW spinor fields, essentially wave functions in the space WCW consisting of Bohr orbit-like 4-surfaces.

Quantum jumps occur between these and the basic problem of standard quantum measurement theory disappears. Ordinary state function reductions (SFRs) correspond to “big” SFRs (BSFRs) in which the arrow of time changes (see **Fig. 22**). This has profound thermodynamic implications and the question about the scale in which the transition from classical to quantum takes place becomes obsolete. BSFRs can occur in all scales but from the point of view of an observer with an opposite arrow of time they look like smooth time evolutions.

In “small” SFRs (SSFRs) as counterparts of “weak measurements” the arrow of time does not change and the passive boundary of CD and states at it remain unchanged (Zeno effect).

Equivalence Principle in TGD framework

There have been also longstanding problems related to the relationship between inertial mass and gravitational mass, whose identification has been far from obvious.

- Gravitational energy is well-defined in cosmological models but is not conserved. Hence the conservation of the inertial energy does not seem to be consistent with the Equivalence Principle. In this framework the quantum numbers are assigned with zero energy states located at the boundaries of CDs defined as intersections of future and past directed light-cones. The notion of energy-momentum becomes length scale dependent since one has a scale hierarchy for causal diamonds. This allows to understand the non-conservation of energy as apparent.

Equivalence Principle in the form expressed by Einstein’s equations follows from Poincare invariance once it is realized that GRT space-time is obtained from the many-sheeted space-time of TGD by lumping together the space-time sheets to a region of Minkowski space and endowing it with an effective metric given as a sum of Minkowski metric and deviations of the metrics of space-time sheets from Minkowski metric. Similar description relates classical gauge potentials identified as components of induced spinor connection to Yang-Mills gauge potentials in GRT space-time. Various topological inhomogenities below resolution scale identified as particles are described using energy momentum tensor and gauge currents.

At quantum level, the Equivalence Principle has a surprisingly strong content. In linear Minkowski coordinates, space-time projection of the M^4 spinor connection representing gravitational gauge potentials the coupling to induced spinor fields vanishes. Also the modified Dirac action for the solutions of the modified Dirac equation seems to vanish identically and in TGD perturbative approach separating interaction terms is not possible.

The modified Dirac equation however fails at the singularities of the minimal surface representing space-time surface and Dirac action reduces to an integral over singularities for the trace of the second fundamental form slashed between the induced spinor field and its conjugate. Also the M^4 part of the trace is non-vanishing and gives rise to the gravitational coupling. The trace gives both standard model vertices and graviton emission vertices. One

could say that at the quantum level gravitational and gauge interactions are eliminated everywhere except at the singularities identifiable as defects of the ordinary smooth structure. The exotic smooth structures [L130], possible only in dimension 4, are ordinary smooth structures apart from these defects serving as vertex representing a creation of a fermion-antifermion pair in the induced gauge potentials. The vertex is universal and essentially the trace of the second fundamental form as an analog of the Higgs field and the gravitational constant is proportional to the square of CP_2 radius.

- There is a delicate difference between inertial and gravitational masses. One can assume that the modes of the imbedding space spinor fields are solutions of massless Dirac equation in either $M^4 \times CP_2$ and therefore eigenstates of inertial momentum or in $CD = cd \times CP_2$: in this case they are only mass eigenstates. The mass spectra are identical for these options. Inertial momenta correspond naturally to the Poincare charges in the space of CDs. For the CD option the spinor modes correspond to mass squared eigenstates for which the mode for H^3 with a given value of light-proper time is a unitary irreducible $SO(1,3)$ representation rather than a representation of translation group. These two eigenmode basis correspond to gravitational basis for spinor modes.

Quantum TGD as a generalization of Einstein's geometrization program

I started the serious attempts to construct quantum TGD after my thesis around 1982. The original optimistic hope was that path integral formalism or canonical quantization might be enough to construct the quantum theory but it turned that this approach fails due to the extreme non-linearity of the theory.

It took some years to discover that the only working approach is based on the generalization of Einstein's program. Quantum physics involves the geometrization of the infinite-dimensional "world of classical worlds" (WCW) identified as the space of 3-dimensional surfaces. Later 3-surfaces were replaced with 4-surfaces satisfying holography and therefore as analogs of Bohr orbits.

- If one assumes Bohr orbitology, then strong correlations between the 3-surfaces at the ends of CD follow and mean holography. It is natural to identify the quantum states of the Universe (and sub-Universes) as modes of a formally classical spinor field in WCW. WCW gamma matrices are expressible in terms of oscillator operators of free second quantized spinor fields of H . The induced spinor fields identified projections of H spinor fields to the space-time surfaces satisfy modified Dirac equation for the modified Dirac equation. Only quantum jump remains the genuinely quantal aspect of quantum physics.
- Quantum TGD can be seen as a theory for free spinor fields in WCW having maximal isometries and the generalization of the Super Virasoro conditions gives rise to the analog massless Dirac equation at the level of WCW.

The world of classical worlds and its symmetries

The notion of "World of Classical Worlds" (WCW) emerged around 1985 but found its basic form around 1990. Holography forced by the realization of General Coordinate Invariance forced/allowed to give up the attempts to make sense of the path integral.

A more concrete way to express this view is that WCW does not consist of 3-surfaces as particle-like entities but almost deterministic Bohr orbits assignable to them as preferred extremals of Kähler action so that quantum TGD becomes wave mechanics in WCW combined with Bohr orbitology. This view has profound implications, which can be formulated in terms of zero energy ontology (ZEO), solving among other things the basic paradox of quantum measurement theory. ZEO forms also the backbone of TGD inspired theory of consciousness and quantum biology.

WCW geometry exists only if it has maximal isometries: this statement is a generalization of the discovery of Freed for loop space geometries [A12]. I have proposed [K60, K32, K142, K102, L159] that WCW could be regarded as a union of generalized symmetric spaces labelled by zero modes which do not contribute to the metric. The induced Kähler field is invariant under symplectic transformations of CP_2 and would therefore define zero mode degrees of freedom if one assumes

that WCW metric has symplectic transformations as isometries. In particular, Kähler magnetic fluxes would define zero modes and are quantized closed 2-surfaces. The induced metric appearing in Kähler action is however not zero mode degree of freedom. If the action contains volume term, the assumption about union of symmetric spaces is not well-motivated.

Symplectic transformations are not the only candidates for the isometries of WCW. The basic picture about what these maximal isometries could be, is partially inspired by string models.

- A weaker proposal is that the symplectomorphisms of H define only symplectomorphisms of WCW. Extended conformal symmetries define also a candidate for isometry group. Remarkably, light-like boundary has an infinite-dimensional group of isometries which are in 1-1 correspondence with conformal symmetries of $S^2 \subset S^2 \times R_+ = \delta M_+^4$.
- Extended Kac Moody symmetries induced by isometries of δM_+^4 are also natural candidates for isometries. The motivation for the proposal comes from physical intuition deriving from string models. Note they do not include Poincare symmetries, which act naturally as isometries in the moduli space of causal diamonds (CDs) forming the "spine" of WCW.
- The light-like orbits of partonic 2-surfaces might allow separate symmetry algebras. One must however notice that there is exchange of charges between interior degrees of freedom and partonic 2-surfaces. The essential point is that one can assign to these surface conserved charges when the dual light-like coordinate defines time coordinate. This picture also assumes a slicing of space-time surface by the partonic orbits for which partonic orbits associated with wormhole throats and boundaries of the space-time surface would be special. This slicing would correspond to Hamilton-Jacobi structure.
- Fractal hierarchy of symmetry algebras with conformal weights, which are non-negative integer multiples of fundamental conformal weights, is essential and distinguishes TGD from string models. Gauge conditions are true only the isomorphic subalgebra and its commutator with the entire algebra and the maximal gauge symmetry to a dynamical symmetry with generators having conformal weights below maximal value. This view also conforms with p-adic mass calculations.
- The realization of the symmetries for 3-surfaces at the boundaries of CD and for light-like orbits of partonic 2-surfaces is known. The problem is how to extend the symmetries to the interior of the space-time surface. It is natural to expect that the symmetries at partonic orbits and light-cone boundary extend to the same symmetries.

After the developments towards the end of 2023, it seems that the extension of conformal and Kac-Moody symmetries of string models to the TGD framework is understood. What about symplectic symmetries, which were originally proposed as isometries of WCW? In this article this question is discussed in detail and it will be found that these symmetries act naturally on 3-D holographic data and one can identify conserved charges. By holography this is in principle enough and might imply that the actions of holomorphic and symplectic symmetry algebras are dual. Holography=holomorphy hypothesis is discussed also in the case of the modified Dirac equation.

About the construction of scattering amplitudes

From the point of view of particle physics the ultimate goal is of course a practical construction recipe for the S-matrix of the theory. I have myself regarded this dream as quite too ambitious taking into account how far-reaching re-structuring and generalization of the basic mathematical structure of quantum physics is required. After having made several guesses for what the counterpart of S-matrix could be, it became clear that the dream about explicit formulas is unrealistic before one has understood what happens in quantum jump.

- In ZEO [K146, L89] one must distinguish between "small" state function reductions (SSFRs) and "big" SFRs (BSFRs). BSFR is the TGD counterpart of the ordinary SFRs and the arrow of the geometric time changes in it. SSFR follows the counterpart of a unitary time evolution and the arrow of the geometric time is preserved in SSFR. The sequence of SSFRs

is the TGD counterpart for the sequence of repeated quantum measurements of the same observables in which nothing happens to the state. In TGD something happens in SSFRs and this gives rise to the flow of consciousness. When the set of the observables measured in SSFR does not commute with the previous set of measured observables, BSFR occurs.

The evolution by SSFRs means that also the causal diamond changes. At quantum level one has a wave function in the finite-dimensional moduli space of CDs which can be said to form a spine of WCW [L155]. CDs form a scale hierarchy. SSFRs are preceded by a dispersion in the moduli space of CDs and SSFR means localization in this space.

- There are several S-matrix like entities. One can assign an analog of the S-matrix to each analog of unitary time evolution preceding a given SSFR. One can also assign an analog S-matrix between the eigenstate basis of the previous set of observables and the eigenstate basis of new observers: this S-matrix characterizes BSFR. One can also assign to zero energy states an S-matrix like entity between the states assignable to the two boundaries of CD. These S-matrix like objects can be interpreted as a complex square root of the density matrix representable as a diagonal and positive square root of density matrix and unitary S-matrix so that quantum theory in ZEO can be said to define a square root of thermodynamics at least formally.

In standard QFTs Feynman diagrams provide the description of scattering amplitudes. The beauty of Feynman diagrams is that they realize unitarity automatically via the so-called Cutkosky rules. In contrast to Feynman's original beliefs, Feynman diagrams and virtual particles are taken only as a convenient mathematical tool in quantum field theories. The QFT approach is however plagued by UV and IR divergences and one must keep mind open for the possibility that a genuine progress might mean opening of the black box of the virtual particle.

In the TGD framework this generalization of Feynman diagrams indeed emerges unavoidably.

- The counterparts of elementary particles can be identified as closed monopole flux tubes connecting two parallel Minkowskian space-time sheets and have effective ends which are Euclidean wormhole contacts. The 3-D light-like boundaries of wormhole contacts as orbits of partonic 2-surfaces.

The intuitive picture is that the 3-D light-like partonic orbits replace the lines of Feynman diagrams and vertices are replaced by 2-D partonic 2-surfaces. A stronger condition is that fermion number is carried by light-like fermion lines at the partonic orbits, which can be identified as boundaries string world sheets.

- The localization of the nodes of induced spinor fields to 2-D string world sheets (and possibly also to partonic 2-surfaces) implies a stringy formulation of the theory analogous to stringy variant of twistor formalism with string world sheets having interpretation as 2-braids. In the TGD framework, the fermionic variant of twistor Grassmann formalism combined with the number theoretic vision [L122, L123] led to a stringy variant of the twistor diagrammatics.
- Fundamental fermions are off-mass-shell in the sense that their momentum components are real algebraic integers in an extension of rationals associated with the space-time surfaces inside CD with a momentum unit determined by the CD size scale. Galois confinement states that the momentum components are integer valued for the physical states.
- The twistorial approach suggests also the generalization of the Yangian symmetry to infinite-dimensional super-conformal algebras, which would determine the vertices and scattering amplitudes in terms of poly-local symmetries.

The twistorial approach is however extremely abstract and lacks a concrete physical interpretation. The holography=holomorphy vision led to a breakthrough in the construction of the scattering amplitudes by solving the problem of identifying interaction vertices [L166].

1. The basic prediction is that space-time surfaces as analogs of Bohr orbits are holomorphic in a generalized sense and are therefore minimal surfaces. The minimal surface property fails at lower-dimensional singularities and the trace of the second fundamental form (SFF) analogous to acceleration associated with the Bohr orbit of the particle as 3-surface has a delta function like singularity but vanishes elsewhere.

2. The minimal surface property expresses masslessness for both fields and particles as 3-surfaces. At singularities masslessness property fails and singularities can be said to serve as sources which also in QFT define scattering amplitudes.
3. The singularities are analogs of poles and cuts for the 4-D generalization of the ordinary holomorphic functions. Also for the ordinary holomorphic functions the Laplace equation as analog massless field equation and expressing analyticity fails. Complex analysis generalizes to dimension 4.
4. The conditions at the singularity give a generalization of Newton's " $F=ma$ "! I ended up where I started more than 50 years ago!
5. In dimension 4, and only there, there is an infinite number of exotic diff structures [?], which differ from ordinary ones at singularities of measure zero analogous to defects. These defects correspond naturally to the singularities of minimal surfaces. One can say that for the exotic diff structure there is no singularity.
6. Group theoretically the trace of the SFF can be regarded as a generalization of the Higgs field, which is non-vanishing only at the vertices and this is enough. Singularities take the role of generalized particle vertices and determine the scattering amplitudes. The second fundamental form contracted with the embedding space gamma matrices and slashed between the second quantized induced spinor field and its conjugate gives the universal vertex involving only fermions (bosons are bound states of fermions in TGD). It contains both gauge and gravitational contributions to the scattering amplitudes and there is a complete symmetry between gravitational and gauge interactions. Gravitational couplings come out correctly as the radius squared of CP_2 as also in the classical picture.
7. The study of the modified Dirac equation leads to the conclusion that vertices as singularities and defects contain the standard electroweak gauge contribution coming from the induced spinor connection and a contribution from the M^4 spinor connection. M^4 part of the generalized Higgs can give rise to a graviton as an $L = 1$ rotational state of the flux tube representing the graviton. It is not clear whether M^4 Kähler gauge potential can give rise to a spin 1 particle. The vielbein part of M^4 spinor connection is pure gauge and could give rise to gravitational topological field theory.

Figures

Basic ideas of TGD inspired quantum biology

The following list gives the basic elements of TGD inspired quantum biology.

- Many-sheeted space-time allows the interpretation of the structures of macroscopic world around us in terms of space-time topology. Magnetic/body acts as intentional agent using biological body as a sensory receptor and motor instrument and controlling biological body and inheriting its hierarchical fractal structure. Fractal hierarchy of EEGs and its variants can be seen as communication and control tools of magnetic body. Also collective levels of consciousness have a natural interpretation in terms of magnetic body. Magnetic body makes also possible entanglement in macroscopic length scales. The braiding of magnetic flux tubes makes possible topological quantum computations and provides a universal mechanism of memory. One can also understand the real function of various information molecules and corresponding receptors by interpreting the receptors as addresses in quantum computer memory and information molecules as ends of flux tubes which attach to these receptors to form a connection in quantum web.

Note that also the notion of electric body makes sense [L145]. Quite generally, long range classical gravitational, electric and magnetic fields give rise to very large values of effective Planck constants. The Nottale's hypothesis of gravitational Planck constant generalizes to electric interactions.

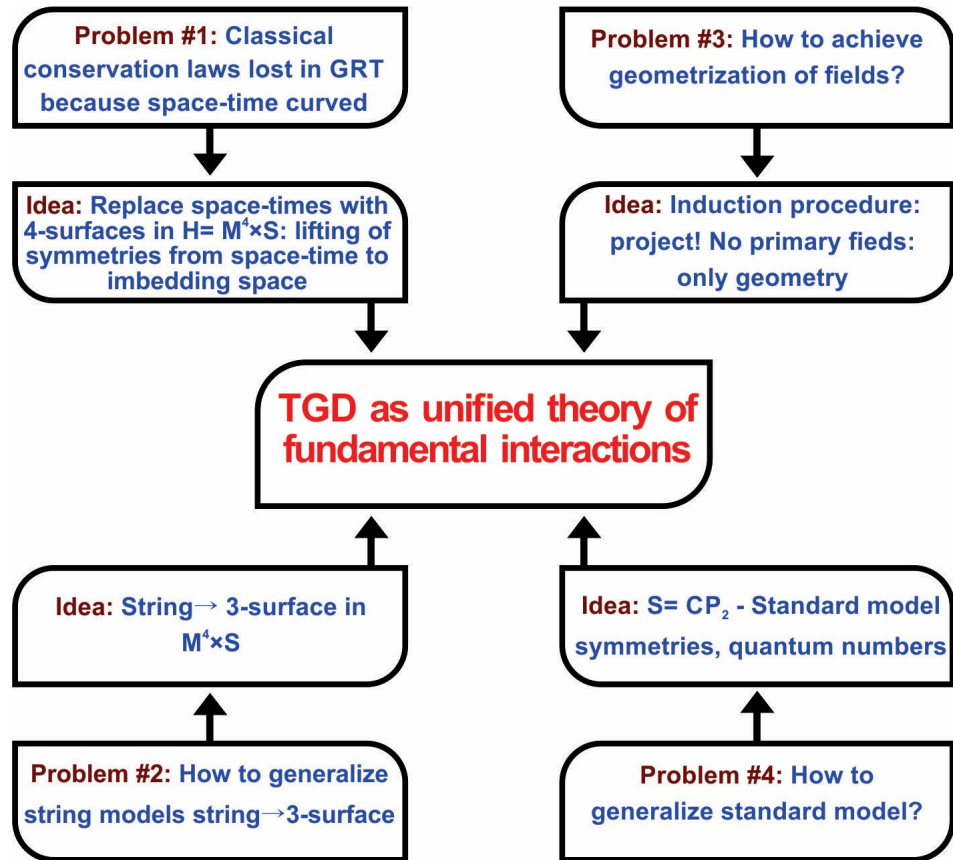


Figure 1: The problems leading to TGD as their solution.

- Magnetic body carrying dark matter and forming an onion-like structure with layers characterized by large values of Planck constant is the key concept of TGD inspired view about Quantum Mind to biology.. Magnetic body is identified as intentional agent using biological body as sensory receptor and motor instrument. EEG and its fractal variants are identified as a communication and control tool of the magnetic body and a fractal hierarchy of analogs of EEG is predicted. Living system is identified as a kind of Indra's net with biomolecules representing the nodes of the net and magnetic flux tubes connections between them.

The reconnection of magnetic flux tubes and phase transitions changing Planck constant and therefore the lengths of the magnetic flux tubes are identified as basic mechanisms behind DNA replication and analogous processes and also behind the phase transitions associated with the gel phase in cell interior. The braiding of magnetic flux makes possible universal memory representation recording the motions of the basic units connected by flux tubes. Braiding also defines topological quantum computer programs updated continually by the flows of the basic units. The model of DNA as topological quantum computer is discussed as an application. In zero energy ontology the braiding actually generalize to 2-braiding for string world sheets in 4-D space-time and brings in new elements.

- Zero energy ontology (ZEO) makes possible the proposed p-adic description of intentions and cognitions and their transformations to action. Time mirror mechanism based on sending of negative energy signal to geometric past would apply to both long term memory recall, remote metabolism, and realization of intentional acting as an activity beginning in the geometric past in accordance with the findings of Libet. ZEO gives a precise content to the notion of negative energy signal in terms of zero energy state for which the arrow of geometric time is opposite to the standard one.

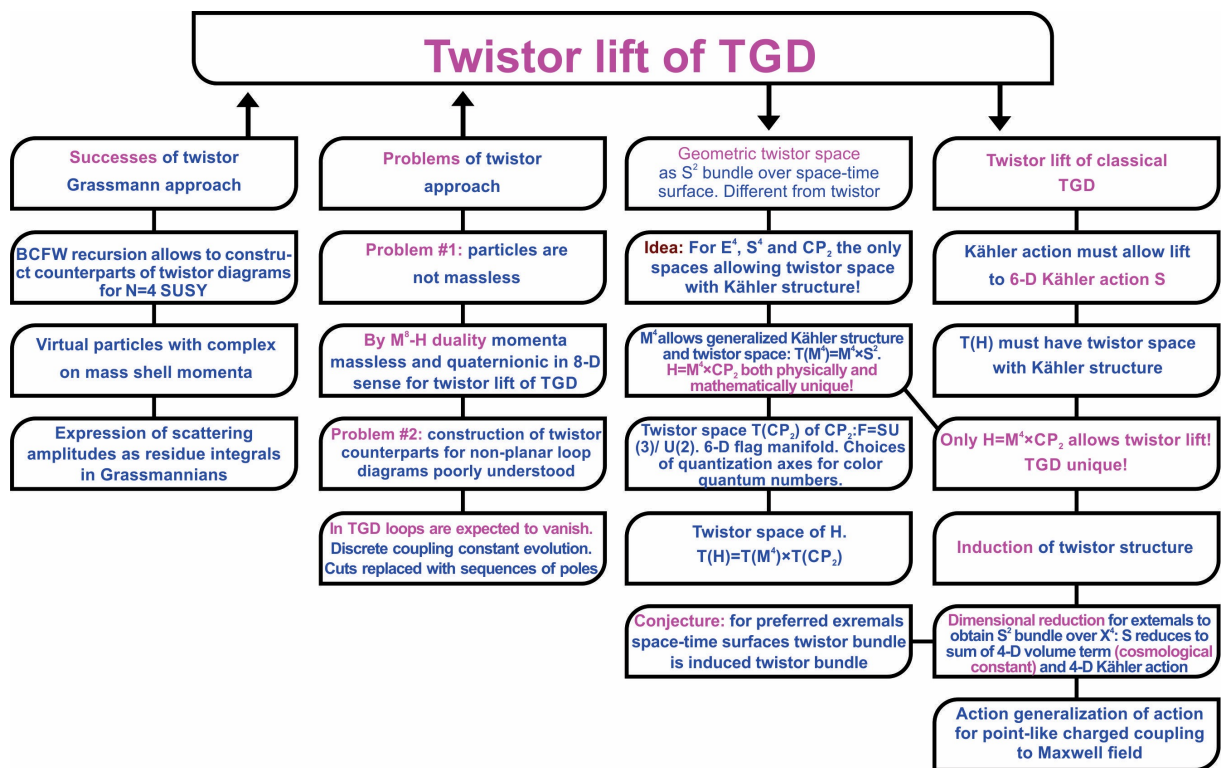


Figure 2: Twistor lift

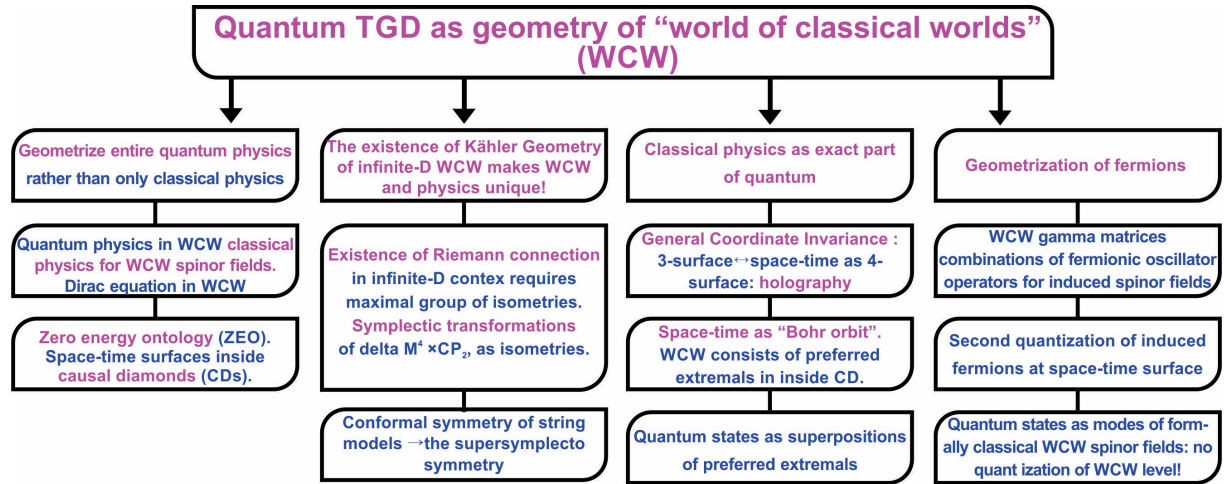
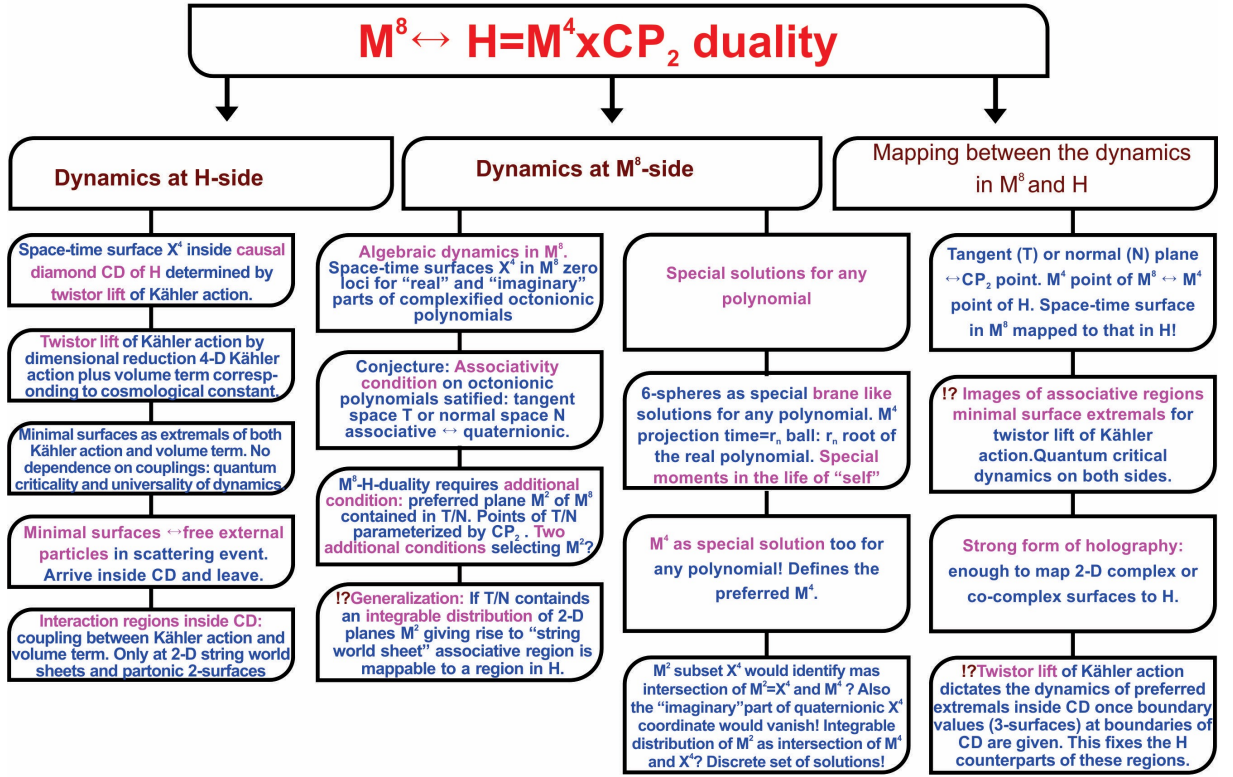


Figure 3: Geometrization of quantum physics in terms of WCW

The associated notion of causal diamond (CD) is essential element and assigns to elementary particles new fundamental time scales which are macroscopic: for electron the time scale is .1 seconds, the fundamental biorhythm. An essentially new element is time-like entanglement which allows to understand among other things the quantum counterparts of Boolean functions in terms of time-like entanglement in fermionic degrees of freedom.

- The assignment of dark matter with a hierarchy of Planck constants gives rise to a hierarchy of macroscopic quantum phases making possible macroscopic and macrotemporal quantum coherence and allowing to understand evolution as a gradual increase of Planck constant. The model for dark nucleons leads to a surprising conclusion: the states of nucleons correspond to DNA, RNA, tRNA, and amino-acids in a natural manner and vertebrate genetic code as correspondence between DNA and amino-acids emerges naturally. This suggests that genetic code is realized at the level of dark hadron physics and living matter in the usual sense provides a secondary representation for it. The hierarchy of Planck constants emerges from basic TGD under rather general assumptions.
- p-Adic physics can be identified as physics of cognition and intentionality. Negentropic entanglement possible for number theoretic entanglement entropy makes sense for rational (and even algebraic) entanglement and leads to the identification of life as something residing in the intersection of real and p-adic worlds. NMP respects negentropic entanglement and the attractive idea is that the experience of understanding and positively colored emotions relate to negentropic entanglement.
- Living matter as conscious hologram is one of the basic ideas of TGD inspired biology and consciousness theory. The basic objection against TGD is that the interference of classical

Figure 4: $M^8 - H$ duality

fields is impossible in the standard sense for the reason that that classical fields are not primary dynamical variables in TGD Universe. The resolution is based on the observation that only the interference of the effects caused by these fields can be observed experimentally and that many-sheeted space-time allows to realized the summation of effects in terms of multiple topological condensations of particles to several parallel space-time sheets. One concrete implication is fractality of qualia. Qualia appear in very wide range of scales: our qualia could in fact be those of magnetic body. The proposed mechanism for the generation of qualia realizes the fractality idea.

Various anomalies of living matter have been in vital role in the development of not only TGD view about living matter but also TGD itself.

- TGD approach to living matter was strongly motivated by the findings about the strange behavior of cell membrane and of cellular water, and gel behavior of cytoplasm. Also the findings about effects of ELF em fields on vertebrate brain were decisive and led to the proposal of the hierarchy of Planck constants found later to emerge naturally from the non-determinism of Kähler action. Rather satisfactorily, the other manner to introduce the hierarchy of Planck constants is in terms of gravitational Planck constant: at least in microscopic scales the equivalence of these approaches makes sense and leads to highly non-trivial predictions. The basic testable prediction is that dark photons have cyclotron frequencies inversely proportional to their masses but universal energy spectrum in visible and UV range which corresponds to the transition energies for biomolecules so that they are ideal for biocontrol at the level of both magnetic bodies and at the level of biochemistry.
- Water is in key role in living matter and also in TGD inspired view about living matter. The

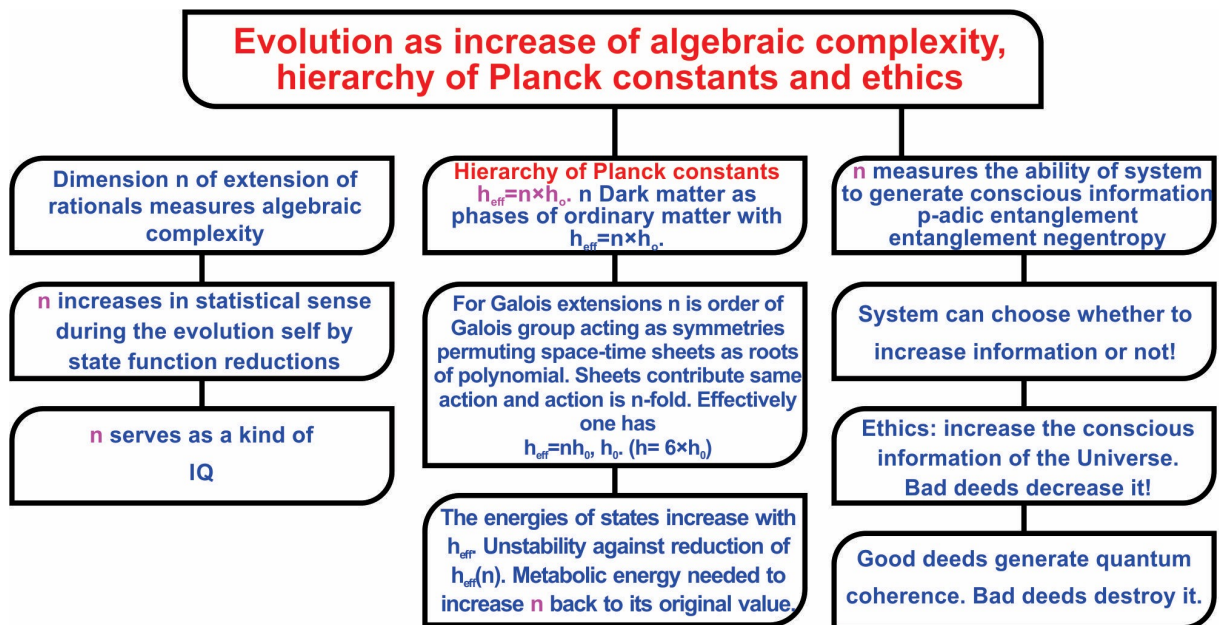


Figure 5: Number theoretic view of evolution

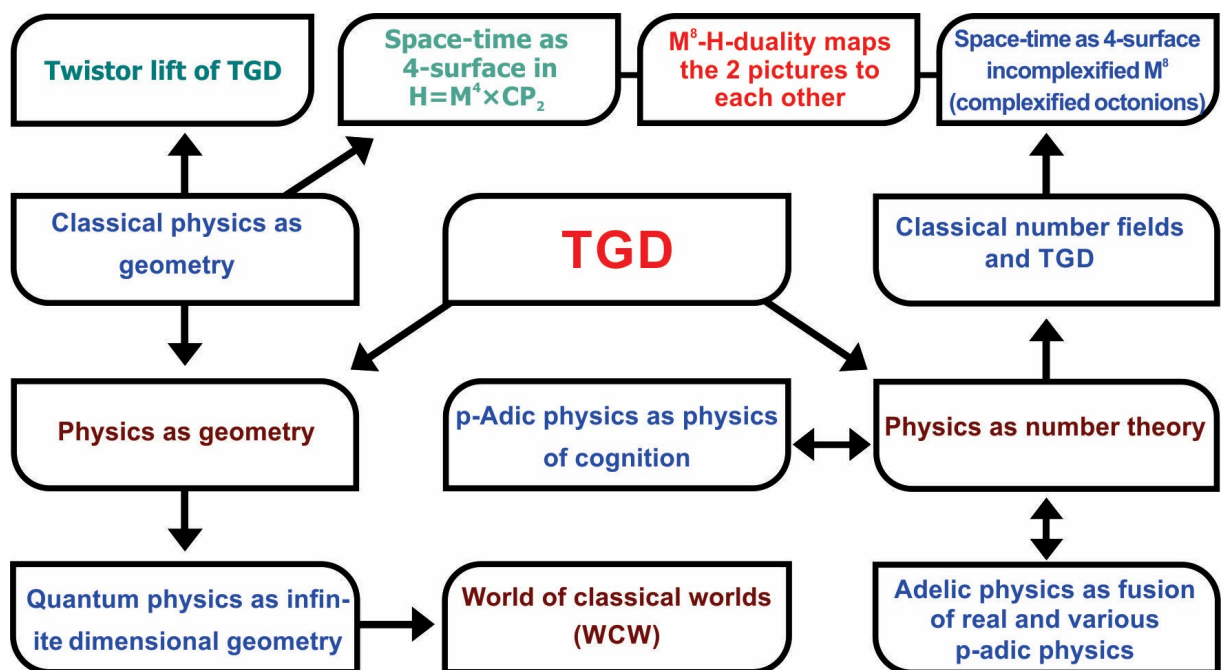


Figure 6: TGD is based on two complementary visions: physics as geometry and physics as number theory.

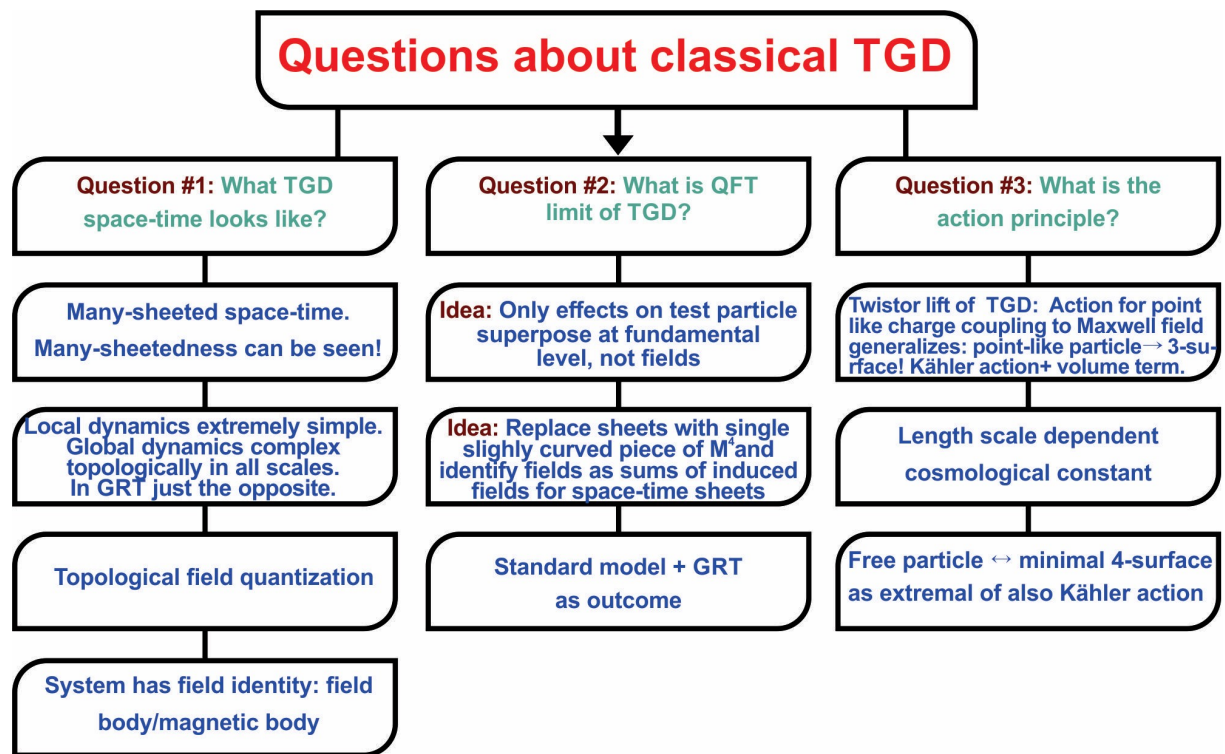


Figure 7: Questions about classical TGD.

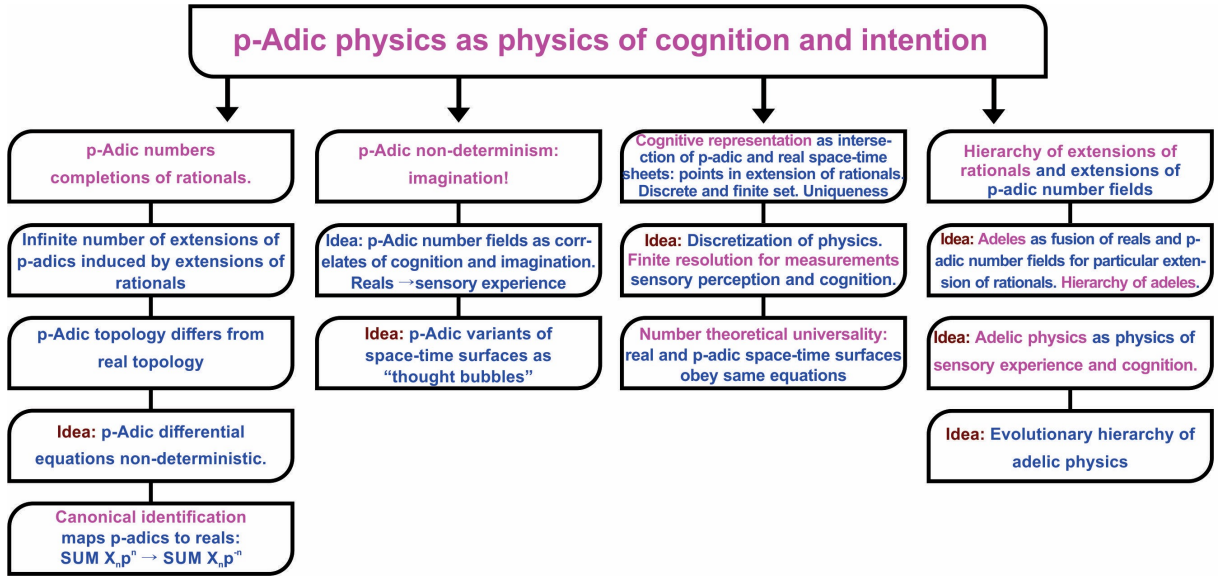


Figure 8: p-Adic physics as physics of cognition and imagination.

anomalies of water lead to a model for dark nuclei as dark proton strings with the surprising prediction that DNA, RNA, amino acids and even tRNA are in one-one correspondence with the resulting 3-quark states and that vertebrate genetic code emerges naturally. This leads to a vision about water as primordial lifeform still playing a vital role in living organisms. The model of water memory and homeopathy in turn generalizes to a vision about how immune system might have evolved.

- Metabolic energy is necessary for conscious information processing in living matter. This suggests that metabolism should be basically transfer of negentropic entanglement from nutrients to the organism. ATP could be seen as a molecule of consciousness in this picture and high energy phosphate bond would make possible the transfer of negentropy.
- Pollack effect and its generalizations are in a central role in the TGD inspired quantum biology. In the Pollack effect, the feed of energy allows to increase the value of effective Planck constant so that an ordinary charged particle transforms to its dark variant, being kicked to, say, the gravitational magnetic body of the system itself or some other system such as the Earth or Sun. Charge separation takes place between ordinary biomatter and its magnetic body. Dissipation is extremely small at the magnetic /field body so that Pollack effect makes it possible to realize various biological functions at the magnetic/field body. Photons, in particular solar photons, can provide the energy needed to increase the value of h_{eff} but there are many other possibilities. For instance, the formation of molecular bound states of atoms liberates energy which can be used in the Pollack effect and this process could generate dark matter at the magnetic and more general field bodies.

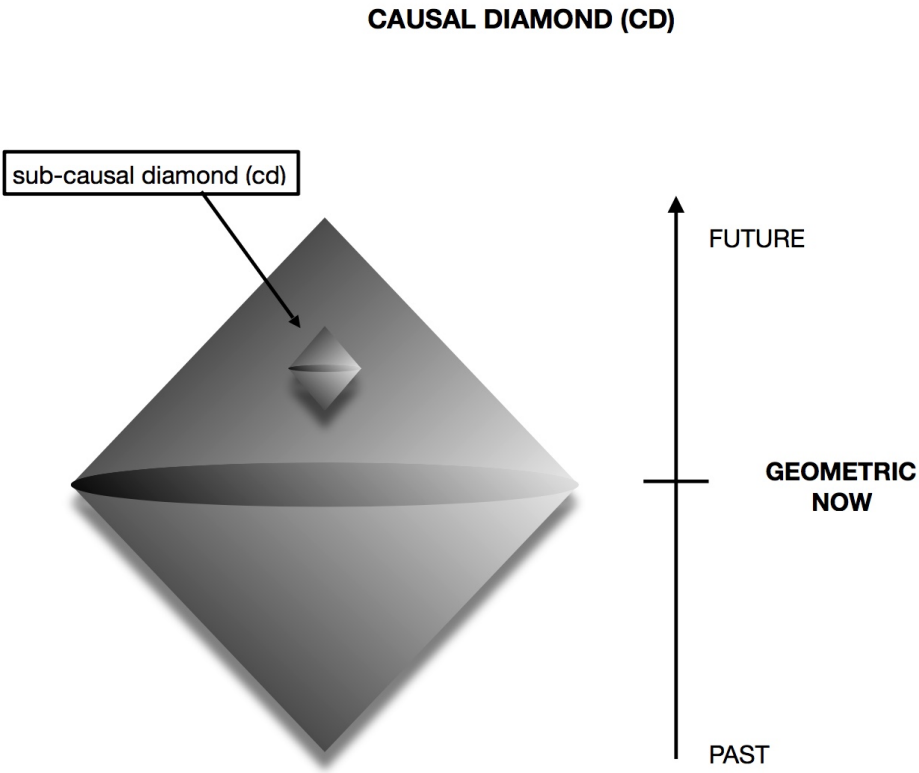


Figure 9: Causal diamond

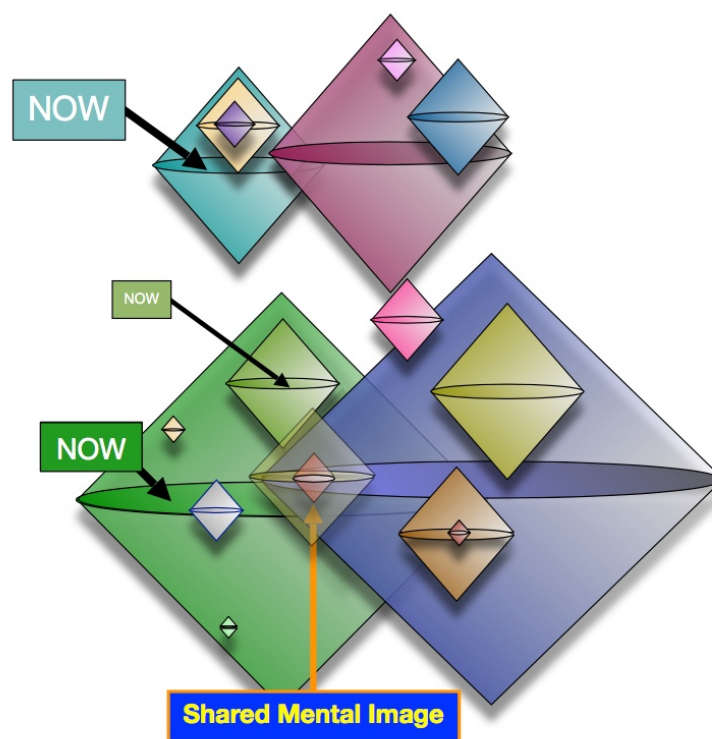


Figure 10: CDs define a fractal “conscious atlas”

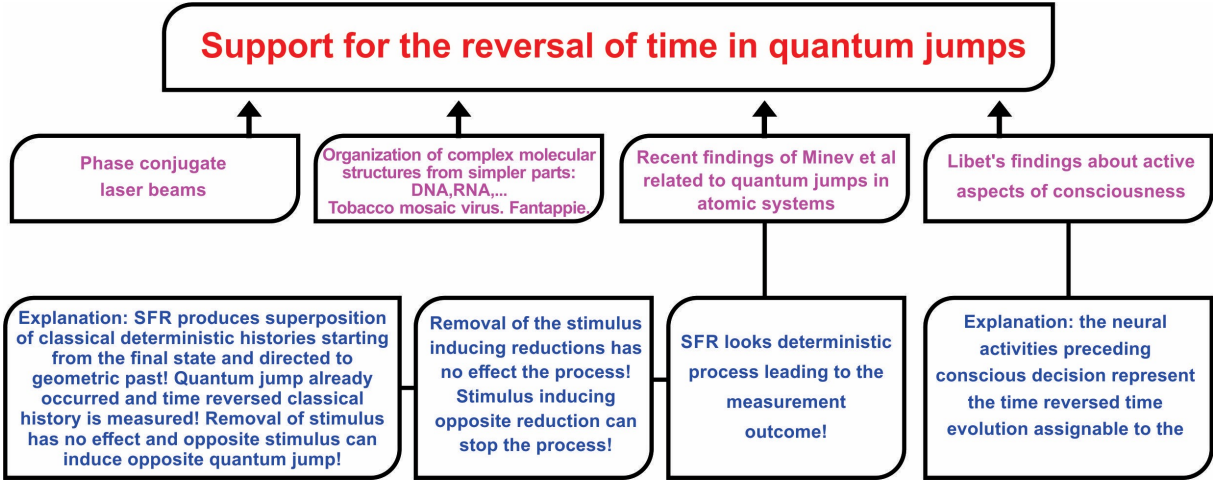


Figure 11: Time reversal occurs in BSFR

Figures

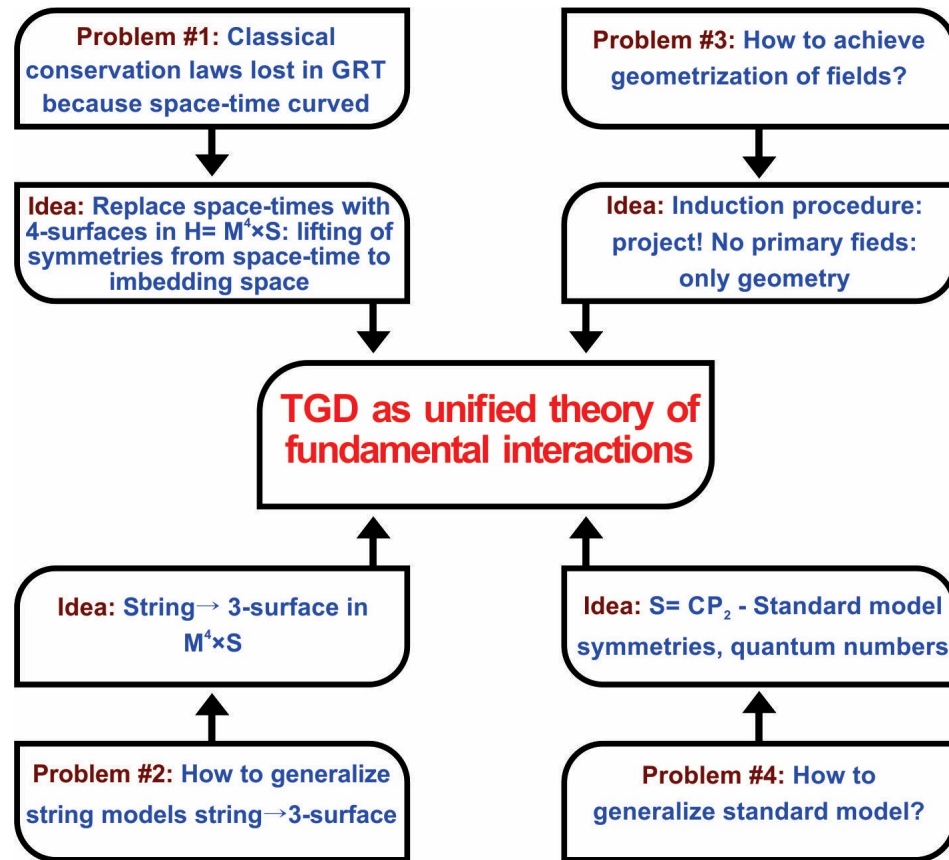


Figure 12: The problems leading to TGD as their solution.

What I have said above is strongly biased view about the recent situation in quantum TGD. This vision is single man's view and doomed to contain unrealistic elements as I know from experience. My dream is that young critical readers could take this vision seriously enough to try to demonstrate that some of its basic premises are wrong or to develop an alternative based on these or better premises. I must be however honest and tell that 45 years of TGD is a really vast bundle of thoughts and quite a challenge for anyone who is not able to cheat himself by taking the attitude of a blind believer or a light-hearted debunker trusting on the power of easy rhetoric tricks.

Karkkila, April 22, 2024, Finland

Matti Pitkänen

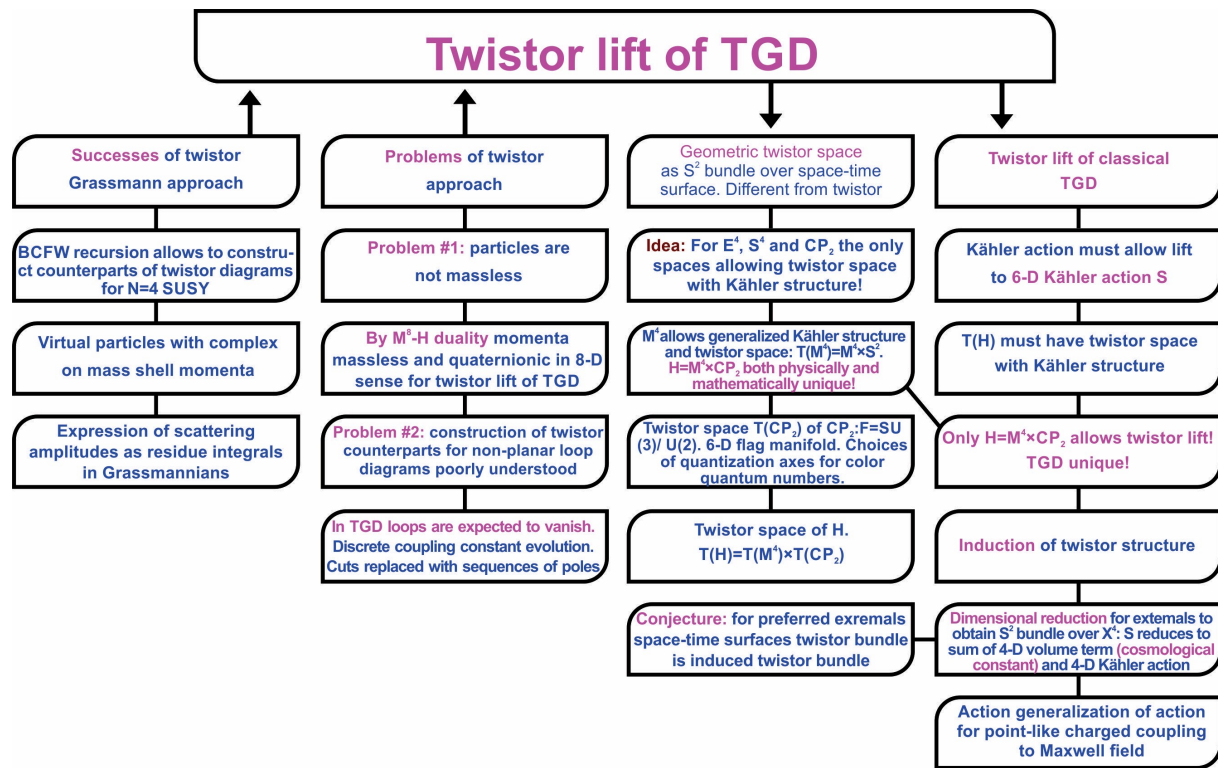


Figure 13: Twistor lift

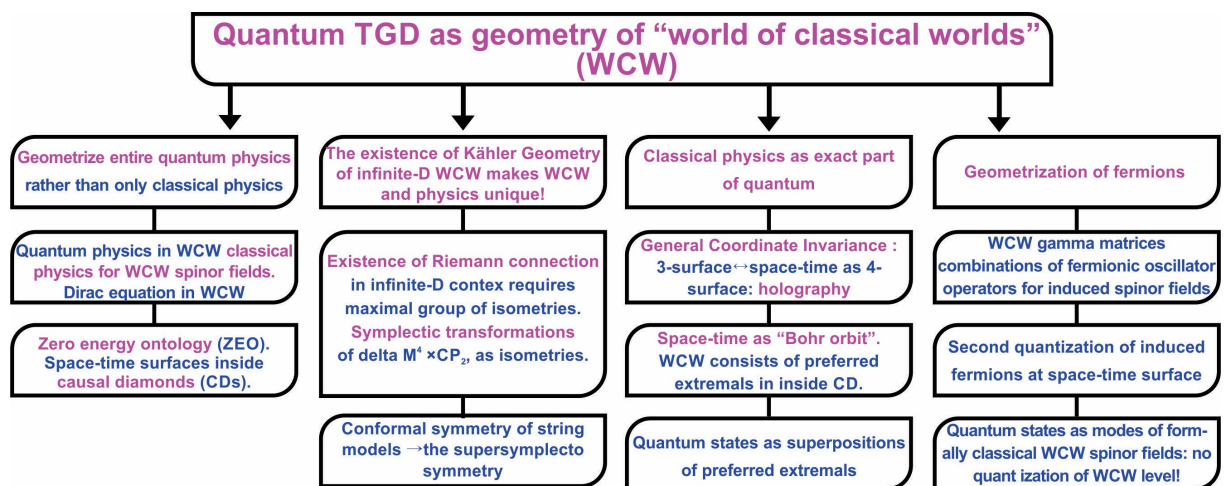
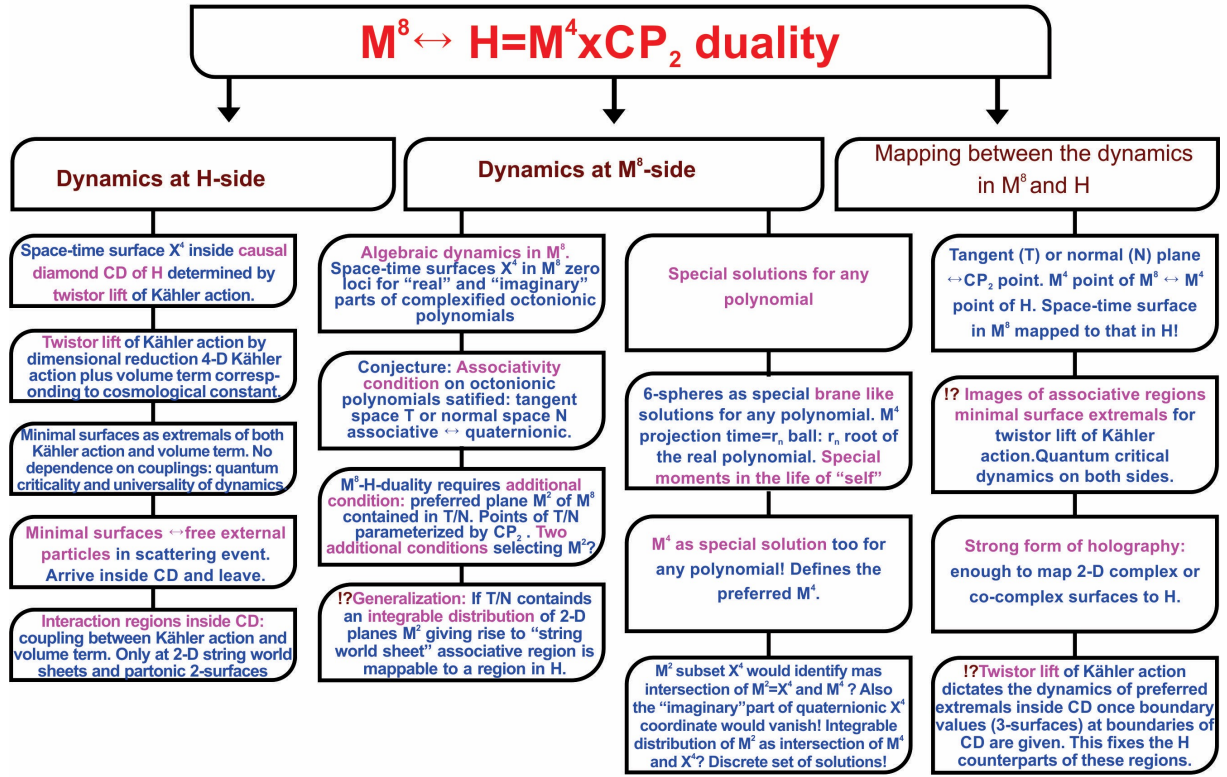


Figure 14: Geometrization of quantum physics in terms of WCW

Figure 15: $M^8 - H$ duality

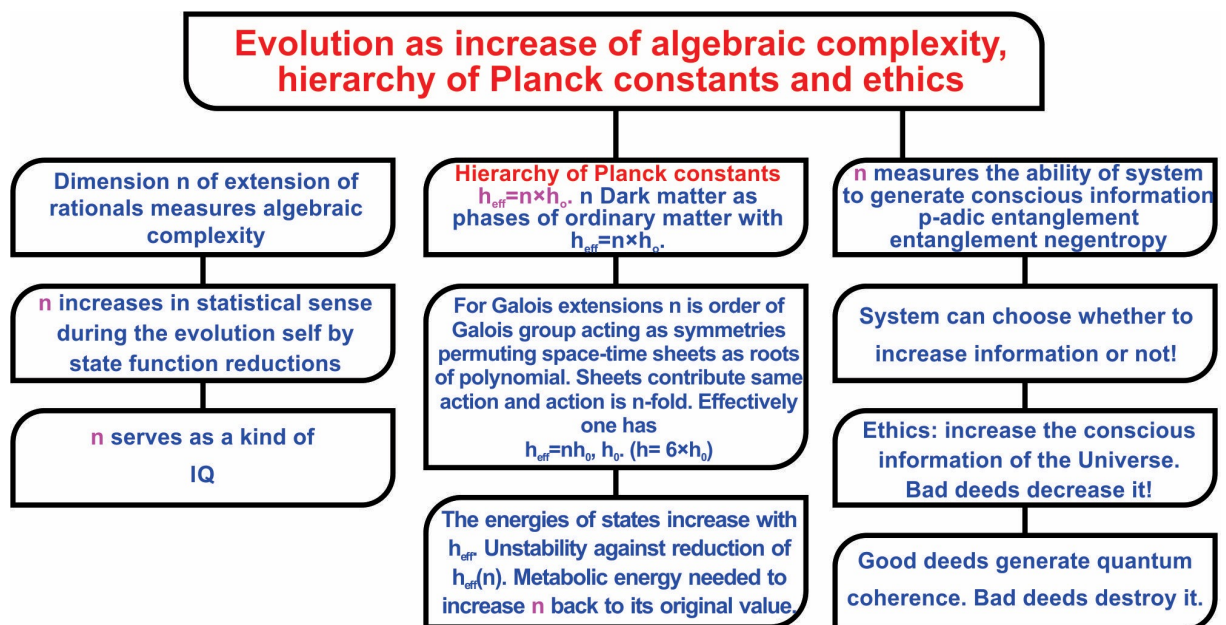


Figure 16: Number theoretic view of evolution

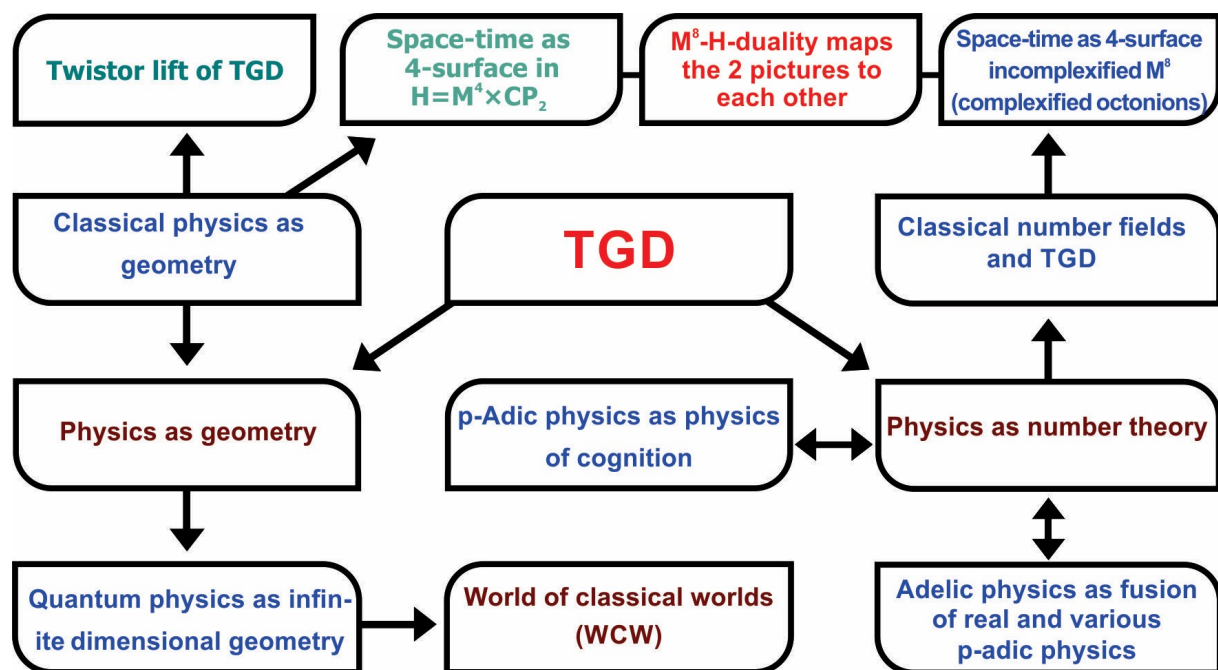


Figure 17: TGD is based on two complementary visions: physics as geometry and physics as number theory.

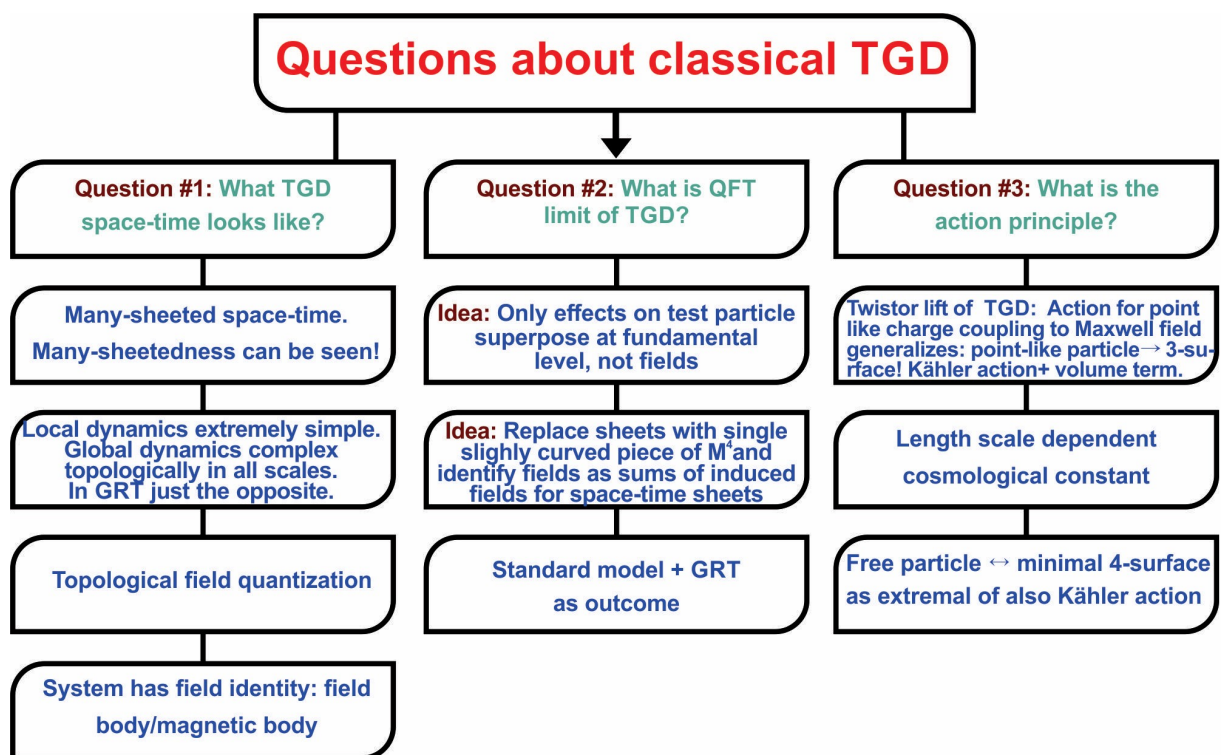


Figure 18: Questions about classical TGD.

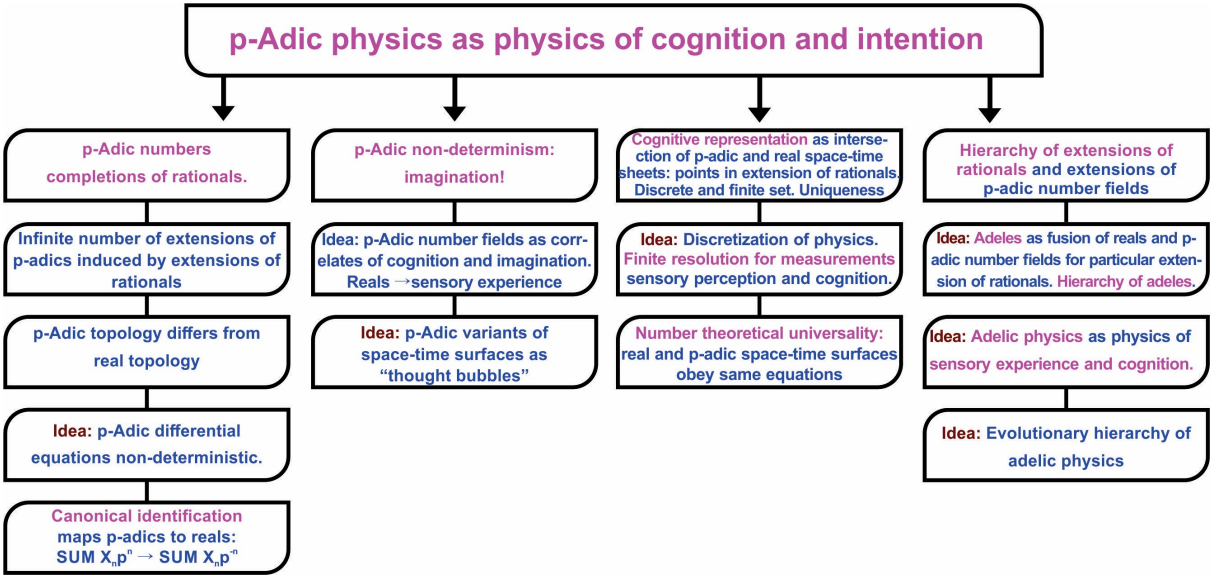


Figure 19: p-Adic physics as physics of cognition and imagination.

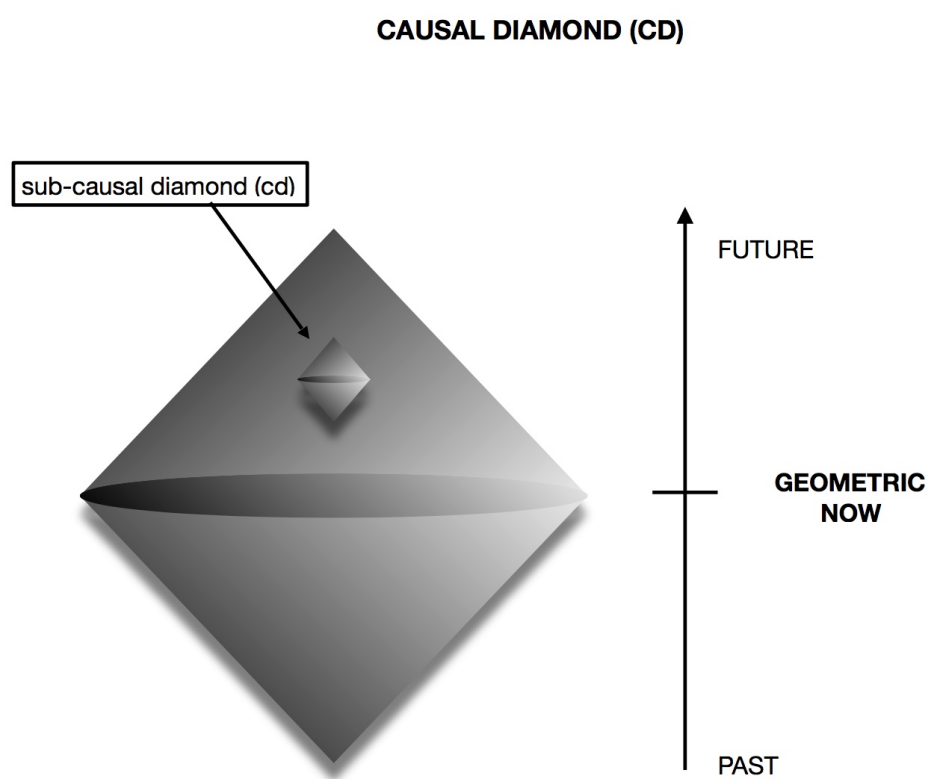


Figure 20: Causal diamond

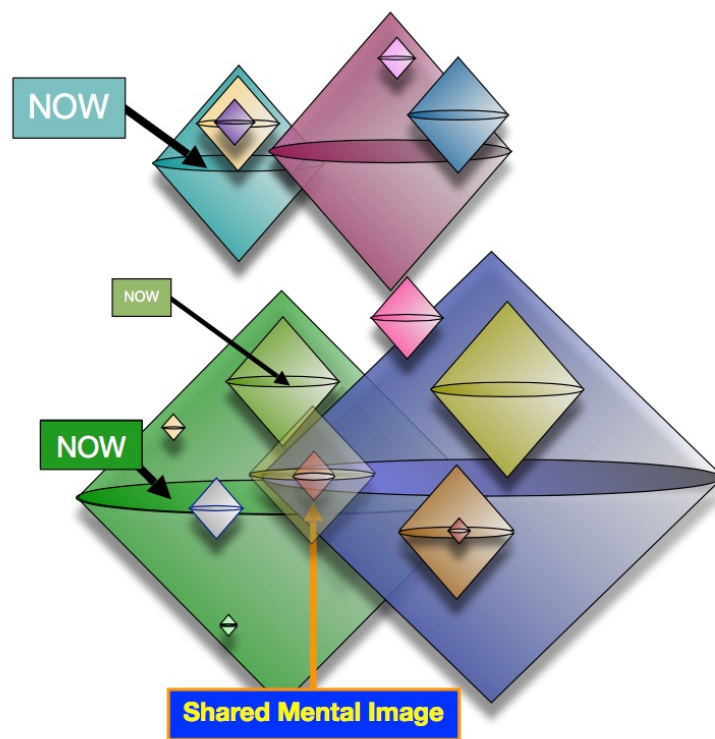


Figure 21: CDs define a fractal “conscious atlas”

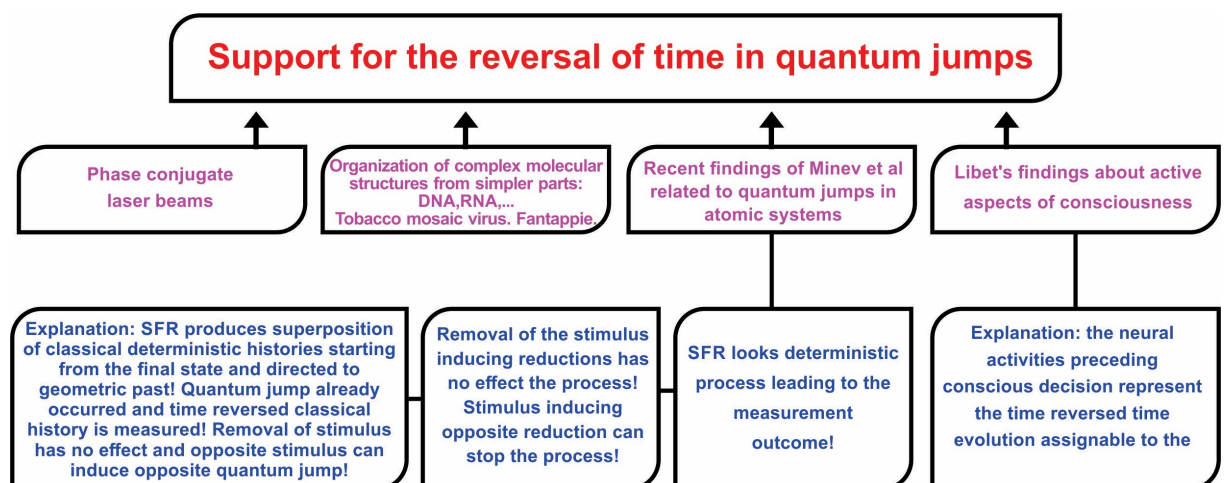


Figure 22: Time reversal occurs in BSFR

ACKNOWLEDGEMENTS

Neither TGD nor these books would exist without the help and encouragement of many people. The friendship with Heikki and Raija Haila and their family and Kalevi and Ritva Tikkanen and their family have been kept me in contact with the everyday world and without this friendship I would not have survived through these lonely 45 lonely years most of which I have remained unemployed as a scientific dissident. I am happy that my children have understood my difficult position and like my friends have believed that what I am doing is something valuable although I have not received any official recognition for it.

During the last decade Tapio Tammi has helped me quite concretely by providing the necessary computer facilities and being one of the few persons in Finland with whom to discuss my work. Pertti Kärkkäinen is my old physicist friend and has provided continued economic support for a long time. I have also had stimulating discussions with Samuli Penttinen who has also helped to get through the economical situations in which there seemed to be no hope. The continual updating of fifteen online books means quite a heavy bureaucracy at the level of bits and without a systemization one ends up with endless copying and pasting and internal consistency is soon lost. Tommi Ullgren has provided both economic support and encouragement during years. Pekka Rapinoja has offered his help in this respect and I am especially grateful to him for my Python skills.

During the last five years I have had inspiring discussions with many people in Finland interested in TGD. We have had video discussions with Sini Kunnas and had podcast discussions with Marko Manninen related to the TGD based view of physics and consciousness. Marko has also helped in the practical issues related to computers and quite recently he has done a lot of testing of chatGPT helping me to get an overall view of what it is. The discussions in a Zoom group involving Marko Manninen, Tuomas Sorakivi and Rode Majakka have given me the valuable opportunity to clarify my thoughts.

The collaboration with Lian Sidorov was extremely fruitful and she also helped me to survive economically through the hardest years. The participation in CASYS conferences in Liege has been an important window to the academic world and I am grateful for Daniel Dubois and Peter Marcer for making this participation possible. The discussions and collaboration with Eduardo de Luna and Istvan Dienes stimulated the hope that the communication of new vision might not be a mission impossible after all. Also blog discussions have been very useful. During these years I have received innumerable email contacts from people around the world. I am grateful to Mark McWilliams, Paul Kirsch, Gary Ehlenberg, and Ulla Matfolk and many others for providing links to possibly interesting websites and articles. We have collaborated with Peter Gariaev and Reza Rastmanesh. These contacts have helped me to avoid the depressive feeling of being some kind of Don Quixote of Science and helped me to widen my views: I am grateful for all these people.

In the situation in which the conventional scientific communication channels are strictly closed it is important to have some loop hole through which the information about the work done can at least in principle leak to the public through the iron wall of academic censorship. Without any exaggeration I can say that without the world wide web I would not have survived as a scientist nor as an individual. Homepage and blog are however not enough since only the formally published result is a result in recent day science. Publishing is however impossible without direct support from power holders- even in archives like arXiv.org.

Situation changed as Andrew Adamatsky proposed the writing of a book about TGD when I had already gotten used to the thought that my work would not be published during my lifetime. The Prespacetime Journal and two other journals related to quantum biology and consciousness - all of them founded by Huping Hu - have provided this kind of loophole. In particular, Dainis Zeps,

Phil Gibbs, and Arkadiusz Jadczyk deserve my gratitude for their kind help in the preparation of an article series about TGD catalyzing a considerable progress in the understanding of quantum TGD. Also the viXra archive founded by Phil Gibbs and its predecessor Archive Freedom have been of great help: Victor Christianto deserves special thanks for doing the hard work needed to run Archive Freedom. Also the Neuroquantology Journal founded by Sultan Tarlaci deserves a special mention for its publication policy.

And last but not least: there are people who experience as a fascinating intellectual challenge to spoil the practical working conditions of a person working with something which might be called unified theory: I am grateful for the people who have helped me to survive through the virus attacks, an activity which has taken roughly one month per year during the last half decade and given a strong hue of grey to my hair.

For a person approaching his 73th birthday it is somewhat easier to overcome the hard feelings due to the loss of academic human rights than for an inpatient youngster. Unfortunately the economic situation has become increasingly difficult during the twenty years after the economic depression in Finland which in practice meant that Finland ceased to be a constitutional state in the strong sense of the word. It became possible to depose people like me from society without fear about public reactions and the classification as dropout became a convenient tool of ridicule to circumvent the ethical issues. During the period when the right wing held political power this trend was steadily strengthening and the situation is the same as I am writing this. In this kind of situation the concrete help from individuals has been and will be of utmost importance. Against this background it becomes obvious that this kind of work is not possible without the support from outside and I apologize for not being able to mention all the people who have helped me during these years.

Karkkila, August 30, 2023, Finland

Matti Pitkänen

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13.10	$(n_0, n_1, n_2) = (2, 12, 6)$ Hamiltonian cycle with 2-fold reflection symmetry.	733
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Chapter 1

Introduction

1.1 Basic Ideas of Topological Geometrodynamics (TGD)

Standard model describes rather successfully both electroweak and strong interactions but sees them as totally separate and contains a large number of parameters which it is not able to predict. For about four decades ago unified theories known as Grand Unified Theories (GUTs) trying to understand electroweak interactions and strong interactions as aspects of the same fundamental gauge interaction assignable to a larger symmetry group emerged. Later superstring models trying to unify even gravitation and strong and weak interactions emerged. The shortcomings of both GUTs and superstring models are now well-known. If TGD - whose basic idea emerged towards the end of 1977 - would emerge now it would be seen as an attempt to solve the difficulties of these approaches to unification.

The basic physical picture behind the geometric vision of TGD corresponds to a fusion of two rather disparate approaches: namely TGD as a Poincare invariant theory of gravitation and TGD as a generalization of the old-fashioned string model. After 1995 number theoretic vision started to develop and was initiated by the success of mass calculations based on p-adic thermodynamics. Number theoretic vision involves all number fields and is complementary to the geometric vision: one can say that this duality is analogous to momentum-position duality of wave mechanics. TGD can be also regarded as topological quantum theory in a very general sense as already the attribute "Topological" in "TGD" makes clear. Space-time surfaces as minimal surfaces can be regarded as representatives of homology equivalence classes and p-adic topologies generalize the notion of local topology and apply to the description of correlates of cognition.

1.1.1 Geometric Vision Very Briefly

T(opological) G(eometro)D(ynamics) is one of the many attempts to find a unified description of basic interactions. The development of the basic ideas of TGD to a relatively stable form took time of about half decade [K2].

The basic vision and its relationship to existing theories is now rather well understood.

1. Space-times are representable as 4-surfaces in the 8-dimensional embedding space $H = M^4 \times CP_2$, where M^4 is 4-dimensional (4-D) Minkowski space and CP_2 is 4-D complex projective space (see Appendix).
2. Induction procedure (a standard procedure in fiber bundle theory, see Appendix) allows to geometrize various fields. Space-time metric characterizing gravitational fields corresponds to the induced metric obtained by projecting the metric tensor of H to the space-time surface. Electroweak gauge potentials are identified as projections of the components of CP_2 spinor connection to the space-time surface, and color gauge potentials as projections of CP_2 Killing vector fields representing color symmetries. Also spinor structure can be induced: induced spinor gamma matrices are projections of gamma matrices of H and induced spinor fields just H spinor fields restricted to space-time surface. Spinor connection is also projected. The interpretation is that distances are measured in embedding space metric and parallel translation using spinor connection of embedding space.

Twistor lift of TGD means that one can lift space-time surfaces in H to 6-D surfaces a analogs of twistor space of space-time surface in the Cartesian product of the twistor spaces of M^4 and CP_2 , which are the only 4-manifolds allowing twistor space with Kähler structure [A19]. The twistor structure would be induced in some sense, and should coincide with that associated with the induced metric. Clearly, the 2-spheres defining the fibers of twistor spaces of M^4 and CP_2 must allow identification: this 2-sphere defines the S^2 fiber of the twistor space of the space-time surface. This poses a constraint on the embedding of the twistor space of space-time surfaces as sub-manifold in the Cartesian product of twistor spaces. The existence of Kähler structure allows to lift 4-D Kähler action to its 6-D counterparts and the 6-D counterpart of twistor space is obtained by its dimensional reduction so that one obtains a sphere bundle. This makes possible twistorialization for all space-time surfaces: in general relativity the general metric does not allow this.

3. A geometrization of quantum numbers is achieved. The isometry group of the geometry of CP_2 codes for the color gauge symmetries of strong interactions. Vierbein group codes for electroweak symmetries, and explains their breaking in terms of CP_2 geometry so that standard model gauge group results. There are also important deviations from the standard model: color quantum numbers are not spin-like but analogous to orbital angular momentum: this difference is expected to be seen only in CP_2 scale. In contrast to GUTs, quark and lepton numbers are separately conserved and family replication has a topological explanation in terms of topology of the partonic 2-surface carrying fermionic quantum numbers.

M^4 and CP_2 are unique choices for many other reasons. For instance, they are the unique 4-D space-times allowing twistor space with Kähler structure. M^4 light-cone boundary allows a huge extension of 2-D conformal symmetries. M^4 and CP_2 allow quaternionic structures. Therefore standard model symmetries have number theoretic meaning.

4. Induced gauge potentials are expressible in terms of embedding space coordinates and their gradients and general coordinate invariance implies that there are only 4 field-like variables locally. Situation is thus extremely simple mathematically. The objection is that one loses linear superposition of fields. The resolution of the problem comes from the generalization of the concepts of particle and space-time.

Space-time surfaces can be also particle like having thus finite size. In particular, space-time regions with Euclidian signature of the induced metric (temporal and spatial dimensions in the same role) emerge and have interpretation as lines of generalized Feynman diagrams. Particles in space-time can be identified as a topological inhomogeneities in background space-time surface which looks like the space-time of general relativity in long length scales.

One ends up with a generalization of space-time surface to many-sheeted space-time with space-time sheets having extremely small distances of about 10^4 Planck lengths (CP_2 size). As one adds a particle to this kind of structure, it touches various space-time sheets and thus interacts with the associated classical fields. Their effects superpose linearly in good approximation and linear superposition of fields is replaced with that for their effects.

This resolves the basic objection. It also leads to the understanding of how the space-time of general relativity and quantum field theories emerges from TGD space-time as effective space-time when the sheets of many-sheeted space-time are lumped together to form a region of Minkowski space with metric replaced with a metric identified as the sum of empty Minkowski metric and deviations of the metrics of sheets from empty Minkowski metric. Gauge potentials are identified as sums of the induced gauge potentials. TGD is therefore a microscopic theory from which the standard model and general relativity follow as a topological simplification, however forcing a dramatic increase of the number of fundamental field variables.

5. A further objection is that classical weak fields identified as induced gauge fields are long ranged and should cause large parity breaking effects due to weak interactions. These effects are indeed observed but only in living matter. The basic problem is that one has long ranged classical electroweak gauge fields. The resolution of the problem is that the quantum averages of induced weak and color gauge fields vanish due to the fact that color rotations affect both space-time surfaces and induced weak and color fields. Only the averages of

electromagnetic fields are nonvanishing. The correlations functions for weak fields are non-vanishing below Compton lengths of weak bosons. In living matter large values of effective Planck constant labelling phases of ordinary matter identified as dark matter make possible long ranged weak fields and color fields.

6. General coordinate invariance requires holography so that space-time surfaces are analogous to Bohr orbits for particles identified as 3-surfaces. Bohr orbit property would be naturally realized by a 4-D generalization of holomorphy of string world sheets and implies that the space-time surfaces are minimal surfaces apart from singularities. This holds true for any action as long as it is general coordinate invariant and constructible in terms of the induced geometry. String world sheets and light-like orbits of partonic 2-surfaces correspond to singularities at which the minimal surface property of the space-time surfaces realizing the preferred extremal property fails. Preferred extremals are not completely deterministic, which implies what I call zero energy ontology (ZEO) meaning that the Bohr orbits are the fundamental objects. This leads to a solution of the basic paradox of quantum measurement theory. Also the mathematically ill-defined path integral disappears and leaves only the well-defined functional integral over the Bohr orbits.
7. A string model-like picture emerges from TGD and one ends up with a rather concrete view about the topological counterpart of Feynman diagrammatics. The natural stringy action would be given by the string world sheet area, which is present only in the space-time regions with Minkowskian signature. Gravitational constant could be present as a fundamental constant in string action and the ratio $\hbar/G/R^2$ would be determined by quantum criticality conditions. The hierarchy of Planck constants $\hbar_{eff}/\hbar = n$ assigned to dark matter in TGD framework would allow to circumvent the objection that only objects of length of order Planck length are possible since string tension given by $T = 1/\hbar_{eff}G$ apart from numerical factor could be arbitrary small. This would make possible gravitational bound states as partonic 2-surfaces as structures connected by strings and solve the basic problem of superstring theories. This option allows the natural interpretation of M^4 type vacuum extremals with CP_2 projection, which is Lagrange manifold as good approximations for space-time sheets at macroscopic length scales. String area does not contribute to the Kähler function at all.

Whether induced spinor fields associated with Kähler-Dirac action and de-localized inside the entire space-time surface should be allowed remains an open question: super-conformal symmetry strongly suggests their presence. A possible interpretation for the corresponding spinor modes could be in terms of dark matter, sparticles, and hierarchy of Planck constants.

It is perhaps useful to make clear what TGD is not and also what new TGD can give to physics.

1. TGD is *not* just General Relativity made concrete by using embeddings: the 4-surface property is absolutely essential for unifying standard model physics with gravitation and to circumvent the incurable conceptual problems of General Relativity. The many-sheeted space-time of TGD gives rise only at the macroscopic limit to GRT space-time as a slightly curved Minkowski space. TGD is *not* a Kaluza-Klein theory although color gauge potentials are analogous to gauge potentials in these theories.

TGD space-time is 4-D and its dimension is due to completely unique conformal properties of light-cone boundary and 3-D light-like surfaces implying enormous extension of the ordinary conformal symmetries. Light-like 3-surfaces represent orbits of partonic 2-surfaces and carry fundamental fermions at 1-D boundaries of string world sheets. TGD is *not* obtained by performing Poincare gauging of space-time to introduce gravitation and is plagued by profound conceptual problems.

2. TGD is *not* a particular string model although string world sheets emerge in TGD very naturally as loci for spinor modes: their 2-dimensionality makes among other things possible quantum deformation of quantization known to be physically realized in condensed matter, and conjectured in TGD framework to be crucial for understanding the notion of finite measurement resolution. Hierarchy of objects of dimension up to 4 emerge from TGD: this obviously means analogy with branes of super-string models.

TGD is *not* one more item in the collection of string models of quantum gravitation relying on Planck length mystics. Dark matter becomes an essential element of quantum gravitation and quantum coherence in astrophysical scales is predicted just from the assumption that strings connecting partonic 2-surfaces are responsible for gravitational bound states.

TGD is *not* a particular string model although AdS/CFT duality of super-string models generalizes due to the huge extension of conformal symmetries and by the identification of WCW gamma matrices as Noether super-charges of super-symplectic algebra having a natural conformal structure.

3. TGD is *not* a gauge theory. In TGD framework the counterparts of also ordinary gauge symmetries are assigned to super-symplectic algebra (and its Yangian [A4] [B11, B9, B10]), which is a generalization of Kac-Moody algebras rather than gauge algebra and suffers a fractal hierarchy of symmetry breakings defining hierarchy of criticalities. TGD is *not* one more quantum field theory like structure based on path integral formalism: path integral is replaced with functional integral over 3-surfaces, and the notion of classical space-time becomes an exact part of the theory. Quantum theory becomes formally a purely classical theory of WCW spinor fields: only state function reduction is something genuinely quantal.
4. TGD view about spinor fields is *not* the standard one. Spinor fields appear at three levels. Spinor modes of the embedding space are analogs of spinor modes characterizing incoming and outgoing states in quantum field theories. Induced second quantized spinor fields at space-time level are analogs of stringy spinor fields. Their modes are localized by the well-definedness of electro-magnetic charge and by number theoretic arguments at string world sheets. Kähler-Dirac action is fixed by supersymmetry implying that ordinary gamma matrices are replaced by what I call Kähler-Dirac gamma matrices - this something new. WCW spinor fields, which are classical in the sense that they are not second quantized, serve as analogs of fields of string field theory and imply a geometrization of quantum theory.
5. TGD is in some sense an extremely conservative geometrization of entire quantum physics: *no* additional structures such as gauge fields as independent dynamical degrees of freedom are introduced: Kähler geometry and associated spinor structure are enough. "Topological" in TGD should not be understood as an attempt to reduce physics to torsion (see for instance [B8]) or something similar. Rather, TGD space-time is topologically non-trivial in all scales and even the visible structures of the everyday world represent non-trivial topology of space-time in the TGD Universe.
6. Twistor space - or rather, a generalization of twistor approach replacing masslessness in 4-D sense with masslessness in 8-D sense and thus allowing description of also massive particles - emerged originally as a technical tool, and its Kähler structure is possible only for $H = M^4 \times CP_2$. It however turned out that much more than a technical tool is in question. What is genuinely new is the infinite-dimensional character of the Kähler geometry making it highly unique, and its generalization to p-adic number fields to describe correlates of cognition. Also the hierarchy of Planck constants $h_{eff} = n \times h$ reduces to the quantum criticality of the TGD Universe and p-adic length scales and Zero Energy Ontology represent something genuinely new.

The great challenge is to construct a mathematical theory around these physically very attractive ideas and I have devoted the last 45 years to the realization of this dream and this has resulted in 26 online books about TGD and nine online books about TGD inspired theory of consciousness and of quantum biology.

A collection of 30 online books is now (August 2023) under preparation. The goal is to minimize overlap between the topics of the books and make the focus of a given book sharper.

1.1.2 Two Visions About TGD as Geometrization of Physics and Their Fusion

As already mentioned, TGD as a geometrization of physics can be interpreted both as a modification of general relativity and generalization of string models.

TGD as a Poincare Invariant Theory of Gravitation

The first approach was born as an attempt to construct a Poincare invariant theory of gravitation. Space-time, rather than being an abstract manifold endowed with a pseudo-Riemannian structure, is regarded as a surface in the 8-dimensional space $H = M^4 \times CP_2$, where M^4 denotes Minkowski space and $CP_2 = SU(3)/U(2)$ is the complex projective space of two complex dimensions [A14, A18, A11, A17].

The identification of the space-time as a sub-manifold [A16, A21] of $M^4 \times CP_2$ leads to an exact Poincare invariance and solves the conceptual difficulties related to the definition of the energy-momentum in General Relativity.

It soon however turned out that sub-manifold geometry, being considerably richer in structure than the abstract manifold geometry, leads to a geometrization of all basic interactions. First, the geometrization of the elementary particle quantum numbers is achieved. The geometry of CP_2 explains electro-weak and color quantum numbers. The different H-chiralities of H -spinors correspond to the conserved baryon and lepton numbers. Secondly, the geometrization of the field concept results. The projections of the CP_2 spinor connection, Killing vector fields of CP_2 and of H -metric to four-surface define classical electro-weak, color gauge fields and metric in X^4 .

The choice of H is unique from the condition that TGD has standard model symmetries. Also number theoretical vision selects $H = M^4 \times CP_2$ uniquely. M^4 and CP_2 are also unique spaces allowing twistor space with Kähler structure.

TGD as a Generalization of the Hadronic String Model

The second approach was based on the generalization of the mesonic string model describing mesons as strings with quarks attached to the ends of the string. In the 3-dimensional generalization 3-surfaces correspond to free particles and the boundaries of the 3-surface correspond to partons in the sense that the quantum numbers of the elementary particles reside on the boundaries. Various boundary topologies (number of handles) correspond to various fermion families so that one obtains an explanation for the known elementary particle quantum numbers. This approach leads also to a natural topological description of the particle reactions as topology changes: for instance, two-particle decay corresponds to a decay of a 3-surface to two disjoint 3-surfaces.

This decay vertex does not however correspond to a direct generalization of trouser vertex of string models. Indeed, the important difference between TGD and string models is that the analogs of string world sheet diagrams do not describe particle decays but the propagation of particles via different routes. Particle reactions are described by generalized Feynman diagrams for which 3-D light-like surface describing particle propagating join along their ends at vertices. As 4-manifolds the space-time surfaces are therefore singular like Feynman diagrams as 1-manifolds.

Quite recently, it has turned out that fermionic strings inside space-time surfaces define an exact part of quantum TGD and that this is essential for understanding gravitation in long length scales. Also the analog of AdS/CFT duality emerges in that the Kähler metric can be defined either in terms of Kähler function identifiable as Kähler action assignable to Euclidian space-time regions or Kähler action + string action assignable to Minkowskian regions.

The recent view about construction of scattering amplitudes is very “stringy”. By strong form of holography string world sheets and partonic 2-surfaces provide the data needed to construct scattering amplitudes. Space-time surfaces are however needed to realize quantum-classical correspondence necessary to understand the classical correlates of quantum measurement. There is a huge generalization of the duality symmetry of hadronic string models.

The proposal is that scattering amplitudes can be regarded as sequences of computational operations for the Yangian of super-symplectic algebra. Product and co-product define the basic vertices and realized geometrically as partonic 2-surfaces and algebraically as multiplication for the elements of Yangian identified as super-symplectic Noether charges assignable to strings. Any computational sequences connecting given collections of algebraic objects at the opposite boundaries of causal diamond (CD) produce identical scattering amplitudes.

Fusion of the Two Approaches via a Generalization of the Space-Time Concept

The problem is that the two approaches to TGD seem to be mutually exclusive since the orbit of a particle like 3-surface defines 4-dimensional surface, which differs drastically from the topologically

trivial macroscopic space-time of General Relativity. The unification of these approaches forces a considerable generalization of the conventional space-time concept. First, the topologically trivial 3-space of General Relativity is replaced with a “topological condensate” containing matter as particle like 3-surfaces “glued” to the topologically trivial background 3-space by connected sum operation. Secondly, the assumption about connectedness of the 3-space is given up. Besides the “topological condensate” there could be “vapor phase” that is a “gas” of particle like 3-surfaces and string like objects (counterpart of the “baby universes” of GRT) and the non-conservation of energy in GRT corresponds to the transfer of energy between different sheets of the space-time and possible existence vapour phase.

. What one obtains is what I have christened as many-sheeted space-time (see **Fig.** <http://tgdtheory.fi/appfigures/manysheeted.jpg> or **Fig.** ?? in the appendix of this book). One particular aspect is topological field quantization meaning that various classical fields assignable to a physical system correspond to space-time sheets representing the classical fields to that particular system. One can speak of the field body of a particular physical system. Field body consists of topological light rays, and electric and magnetic flux quanta. In Maxwell’s theory the physical system does not possess this kind of field identity. The notion of the magnetic body is one of the key players in TGD inspired theory of consciousness and quantum biology. The existence of monopole flux tubes requiring no current as a source of the magnetic field makes it possible to understand the existence of magnetic fields in cosmological and astrophysical scales.

This picture became more detailed with the advent of zero energy ontology (ZEO). The basic notion of ZEO is causal diamond (CD) identified as the Cartesian product of CP_2 and of the intersection of future and past directed light-cones and having scale coming as an integer multiple of CP_2 size is fundamental. CDs form a fractal hierarchy and zero energy states decompose to products of positive and negative energy parts assignable to the opposite boundaries of CD defining the ends of the space-time surface. The counterpart of zero energy state in positive energy ontology is the pair of initial and final states of a physical event, say particle reaction.

At space-time level ZEO means that 3-surfaces are pairs of space-like 3-surfaces at the opposite light-like boundaries of CD. Since the extremals of Kähler action connect these, one can say that by holography the basic dynamical objects are the space-time surface connecting these 3-surfaces and identifiable as analogs of Bohr orbits. This changes totally the vision about notions like self-organization: self-organization by quantum jumps does not take for a 3-D system but for the entire 4-D field pattern associated with it.

General Coordinate Invariance (GCI) allows to identify the basic dynamical objects as space-like 3-surfaces at the ends of space-time surface at boundaries of CD: this means that space-time surface is analogous to Bohr orbit. An alternative identification of the lines of generalized Feynman diagrams is as light-like 3-surfaces at which the signature of the induced metric changes from Minkowskian to Euclidian. Also the Euclidian 4-D regions can have a similar interpretation. The requirement that the two interpretations are equivalent, leads to a strong form of General Coordinate Invariance. The outcome is effective 2-dimensionality stating that the partonic 2-surfaces identified as intersections of the space-like ends of space-time surface and light-like wormhole throats are the fundamental objects. That only effective 2-dimensionality is in question is due to the effects caused by the failure of strict determinism of Kähler action. In finite length scale resolution these effects can be neglected below UV cutoff and above IR cutoff. One can also speak about a strong form of holography.

The understanding of the super symplectic invariance leads to the proposal that super symplectic algebra and other Kac-Moody type algebras labelled by non-negative multiples of basic conformal weights allow a hierarchy of symmetry breakings in which the analog of gauge symmetry breaks down to a genuine dynamical symmetry. This gives rise to fractal hierarchies of algebras and symmetry breakings. This breaking can occur also for ordinary conformal algebras if one restricts the conformal weights to be non-negative integers.

1.1.3 Basic Objections

Objections are the most powerful tool in theory building. The strongest objection against TGD is the observation that all classical gauge fields are expressible in terms of four embedding space coordinates only- essentially CP_2 coordinates. The linear superposition of classical gauge fields taking place independently for all gauge fields is lost. This would be a catastrophe without many-

sheeted space-time. Instead of gauge fields, only the effects such as gauge forces are superposed. Particles topologically condense to several space-time sheets simultaneously and experience the sum of gauge forces. This transforms the weakness to extreme economy: in a typical unified theory the number of primary field variables is countered in hundreds if not thousands, now it is just four.

Second objection is that TGD space-time is quite too simple as compared to GRT space-time due to the embeddability to 8-D embedding space. One can also argue that Poincare invariant theory of gravitation cannot be consistent with General Relativity. The above interpretation makes it possible to understand the relationship to GRT space-time and how the Equivalence Principle (EP) follows from Poincare invariance of TGD. The interpretation of GRT space-time is as effective space-time obtained by replacing many-sheeted space-time with Minkowski space with effective metric determined as a sum of Minkowski metric and sum over the deviations of the induced metrics of the space-time sheets from Minkowski metric. Poincare invariance strongly suggests classical EP for the GRT limit in long length scales at least. One can also consider other kinds of limits such as the analog of GRT limit for Euclidian space-time regions assignable to elementary particles. In this case deformations of CP_2 metric define a natural starting point and CP_2 indeed defines a gravitational instanton with a very large cosmological constant in Einstein-Maxwell theory. Also gauge potentials of the standard model correspond classically to superpositions of induced gauge potentials over space-time sheets.

Topological Field Quantization

Topological field quantization distinguishes between TGD based and more standard - say Maxwellian - notion of field. In Maxwell's fields created by separate systems superpose and one cannot tell which part of field comes from which system except theoretically. In TGD these fields correspond to different space-time sheets and only their effects on test particle superpose. Hence physical systems have well-defined field identifies - field bodies - in particular magnetic bodies.

The notion of magnetic body carrying dark matter with non-standard large value of Planck constant has become central concept in TGD inspired theory of consciousness and living matter, and by starting from various anomalies of biology one ends up to a rather detailed view about the role of magnetic body as intentional agent receiving sensory input from the biological body and controlling it using EEG and its various scaled up variants as a communication tool. Among other things this leads to models for cell membrane, nerve pulse, and EEG.

1.1.4 Quantum TGD as Spinor Geometry of World of Classical Worlds

A turning point in the attempts to formulate a mathematical theory was reached after seven years from the birth of TGD. The great insight was "Do not quantize". The basic ingredients to the new approach have served as the basic philosophy for the attempt to construct Quantum TGD since then and have been the following ones.

World of Classical Worlds

The notion of WCW reduces the interacting quantum theory to a theory of free WCW spinor fields.

1. Quantum theory for extended particles is free(!), classical(!) field theory for a generalized Schrödinger amplitude identified as WCW spinor in the configuration space CH ("world of classical worlds", WCW) consisting of all possible 3-surfaces in H . "All possible" means that surfaces with arbitrary many disjoint components and with arbitrary internal topology and also singular surfaces topologically intermediate between two different manifold topologies are included.
2. 4-D general coordinate invariance forces holography and replaces the ill-defined path integral over all space-time surfaces with a discrete sum over 4-D analogs of Bohr orbits for particles identified as 3-surfaces. Holography means that basic objects are these analogs of Bohr orbits. Since there is no quantization at the level of WCW, one has an analog of wave mechanics with point-like particles replaced with 4-D Bohr orbits.

3. One must geometrize WCW as the space of Bohr orbits. In an infinite-dimensional situation the existence of geometry requires maximal symmetries already in the case of loop spaces. Physics is unique from its mathematical existence.

WCW is endowed with metric and spinor structure so that one can define various metric related differential operators, say Dirac operators, appearing in the field equations of the theory ¹

Identification of Kähler function

The evolution of these basic ideas has been rather slow but has gradually led to a rather beautiful vision. One of the key problems has been the definition of Kähler function. Kähler function is Kähler action for a preferred extremal assignable to a given 3-surface but what this preferred extremal is? The obvious first guess was as absolute minimum of Kähler action but could not be proven to be right or wrong. One big step in the progress was boosted by the idea that TGD should reduce to almost topological QFT in which braids would replace 3-surfaces in finite measurement resolution, which could be inherent property of the theory itself and imply discretization at partonic 2-surfaces with discrete points carrying fermion number.

It took long time to realize that there is no discretization in 4-D sense - this would lead to difficulties with basic symmetries. Rather, the discretization occurs for the parameters characterizing co-dimension 2 objects representing the information about space-time surface so that they belong to some algebraic extension of rationals. These 2-surfaces - string world sheets and partonic 2-surfaces - are genuine physical objects rather than a computational approximation. Physics itself approximates itself, one might say! This is of course nothing but strong form of holography.

1. TGD as almost topological QFT vision suggests that Kähler action for preferred extremals reduces to Chern-Simons term assigned with space-like 3-surfaces at the ends of space-time (recall the notion of causal diamond (CD)) and with the light-like 3-surfaces at which the signature of the induced metric changes from Minkowskian to Euclidian. Minkowskian and Euclidian regions would give at wormhole throats the same contribution apart from coefficients and in Minkowskian regions the $\sqrt{g_4}$ factor coming from metric would be imaginary so that one would obtain sum of real term identifiable as Kähler function and imaginary term identifiable as the ordinary Minkowskian action giving rise to interference effects and stationary phase approximation central in both classical and quantum field theory.

Imaginary contribution - the presence of which I realized only after 33 years of TGD - could also have topological interpretation as a Morse function. On physical side the emergence of Euclidian space-time regions is something completely new and leads to a dramatic modification of the ideas about black hole interior.

2. The way to achieve the reduction to Chern-Simons terms is simple. The vanishing of Coulomb contribution to Kähler action is required and is true for all known extremals if one makes a general ansatz about the form of classical conserved currents. The so called weak form of electric-magnetic duality defines a boundary condition reducing the resulting 3-D terms to Chern-Simons terms. In this way almost topological QFT results. But only “almost” since the Lagrange multiplier term forcing electric-magnetic duality implies that Chern-Simons action for preferred extremals depends on metric.

WCW spinor fields

Classical WCW spinor fields are analogous to Schrödinger amplitudes and the construction of WCW Kähler geometry reduces to the second quantization of free spinor fields of H .

¹There are four kinds of Dirac operators in TGD. The geometrization of quantum theory requires Kähler metric definable either in terms of Kähler function identified as the bosonic action for Euclidian space-time regions or as anti-commutators for WCW gamma matrices identified as conformal Noether super-charges associated with the second quantized modified Dirac action consisting of string world sheet term and possibly also modified Dirac action in Minkowskian space-time regions. These two possible definitions reflect a duality analogous to AdS/CFT duality.

1. The WCW metric is given by anticommutators of WCW gamma matrices which also have interpretation as supercharges assignable to the generators of WCW isometries and allowing expression as non-conserved Noether charges. Holography implies zero energy ontology (ZEO) meaning that zero energy states are superpositions of Bohr orbits connecting boundaries of causal diamond (CD). CDs form a fractal hierarchy and their space forming the spine of WCW is finite-dimensional and can be geometrized. The alternative interpretation is as a superposition of pairs of ordinary 3-D fermionic states assignable to the ends of the space-time surfaces.
2. There are several Dirac operators. WCW Dirac operator D_{WCW} appears in Super-symplectic gauge conditions analogous to Super Virasoro conditions. The algebraic variant of the H Dirac operator D_H appears in fermionic correlation functions: this is due to the fact that free fermions appearing as building bricks of WCW gamma matrices are modes of D_H . The modes of D_H define the ground states of super-symplectic representations. There is also the modified Dirac operator D_{X^4} acting on the induced spinors at space-time surfaces and it is dictated by symmetry one the action fixing the space-time surfaces as Bohr orbits is fixed. D_H is needed since it determines the expressions of WCW gamma matrices as Noether charges assignable to 3-surfaces at the ends of WCW.

The role of modified Dirac action

1. By quantum classical correspondence, the construction of WCW spinor structure in sectors assignable to CDs reduces to the second quantization of the induced spinor fields of H . The basic action is so called modified Dirac action in which gamma matrices are replaced with the modified gamma matrices defined as contractions of the canonical momentum currents of the bosonic action defining the space-time surfaces with the embedding space gamma matrices. In this way one achieves super-conformal symmetry and conservation of fermionic currents among other things and a consistent Dirac equation.

Modified Dirac action is needed to define WCW gamma matrices as super charges assignable to WCW isometry generators identified as generators of symplectic transformations and by holography are needed only at the 3-surface at the boundaries of WCW. It is important to notice that the modified Dirac equation does not determine propagators since induced spinor fields are obtained from free second quantized spinor fields of H . This means enormous simplification and makes the theory calculable.

2. An important interpretational problem relates to the notion of the induced spinor connection. The presence of classical W boson fields is in conflict with the classical conservation of em charge since the coupling to classical W fields changes em charge.

One way out of the problem is the fact that the quantum averages of weak and gluon fields vanish unlike the quantum average of the em field. This leads to a rather precise understanding of electroweak symmetry breaking as being due the fact that color symmetries rotate space-time surfaces and also affect the induced weak fields.

One can also consider a stronger condition. If one requires that the spinor modes have well-defined em charge, one must assume that the modes in the generic situation are localized at 2-D surfaces - string world sheets or perhaps also partonic 2-surfaces - at which classical W boson fields vanish. Covariantly constant right handed neutrinos generating super-symmetries forms an exception. The vanishing of the Z^0 field is possible for Kähler-Dirac action and should hold true at least above weak length scales. This implies that the string model in 4-D space-time becomes part of TGD. Without these conditions classical weak fields can vanish above weak scale only for the GRT limit of TGD for which gauge potentials are sums over those for space-time sheets.

The localization would simplify the mathematics enormously and one can solve exactly the Kähler-Dirac equation for the modes of the induced spinor field just like in super string models.

At the light-like 3-surfaces the signature of the induced metric changes from Euclidian to Minkowskian so that $\sqrt{g_4}$ vanishes. One can pose the condition that the algebraic analog of

the massless Dirac equation is satisfied by the modes of the modified-Dirac action assignable to the Chern-Simons-Kähler action.

1.1.5 Construction of scattering amplitudes

Reduction of particle reactions to space-time topology

Particle reactions are identified as topology changes [A20, A22, A25]. For instance, the decay of a 3-surface to two 3-surfaces corresponds to the decay $A \rightarrow B + C$. Classically this corresponds to a path of WCW leading from 1-particle sector to 2-particle sector. At quantum level this corresponds to the dispersion of the generalized Schrödinger amplitude localized to 1-particle sector to two-particle sector. All coupling constants should result as predictions of the theory since no nonlinearities are introduced.

During years this naïve and very rough vision has of course developed a lot and is not anymore quite equivalent with the original insight. In particular, the space-time correlates of Feynman graphs have emerged from theory as Euclidian space-time regions and the strong form of General Coordinate Invariance has led to a rather detailed and in many respects un-expected visions. This picture forces to give up the idea about smooth space-time surfaces and replace space-time surface with a generalization of Feynman diagram in which vertices represent the failure of manifold property. I have also introduced the word “world of classical worlds” (WCW) instead of rather formal “configuration space”. I hope that “WCW” does not induce despair in the reader having tendency to think about the technicalities involved!

Construction of the counterparts of S-matrices

What does one mean with the counterpart of S-matrix in the TGD framework has been a long standing problem. The development of ZEO based quantum measurement theory has led to a rough overall view of the situation.

1. There are two kinds of state function reductions (SFRs). “Small” SFRs (SSFRs) following the TGD counterpart of a unitary time evolution defines a sequence of SFRs, which is analogous to a sequence of repeated quantum measurements associated with the Zeno effect. In wave mechanics nothing happens in these measurements. In quantum optics these measurements correspond to weak measurements. In TGD SSFR affects the zero energy state but leaves the 3-D state at the passive boundary of CD unaffected.
2. In TGD framework each SSFR is preceded by a counterpart of a unitary time evolution, which means dispersion in the space of CDs and unitary time evolution in fermionic degrees of freedom such that the passive boundary of CDs and 3-D states at it are unaffected but a superposition of CDs with varying active boundaries in the space of CDs is formed. In SSFR a localization in the space of CDs occurs such that the active is fixed. In a statistical sense the size of the CD increases and the increasing distance between the tips of the CD gives rise to the arrow of geometric time.
3. Also “big” SFRs (BSFRs) can occur and they correspond to ordinary SFRs. In BSFR the roles of the active and passive boundary are changed and this means that the arrow of time is changed. Big SFR occurs when the SSFR corresponds to a quantum measurement, which does not commute with the operators, which define the states at the passive boundary of CD as their eigenstates. This means a radical deviation from standard quantum measurement theory and has predictions in all scales.
4. One can assign the counterpart of S-matrix to the unitary time evolution between two subsequent SSFRs and also to the counterpart of S-matrix associated with BSFR. At least in the latter case the dimension of the state space can increase since at least BSFRs lead to the increase of the dimension of algebraic extension of rationals assignable to the space-time surface by $M^8 - H$ duality. Unitarity is therefore replaced with isometry.
5. I have also considered the possibility that unitary S-matrix could be replaced in the fermionic degrees of freedom with Kähler metric of the state space satisfying analogs of unitarity conditions but it seems that this is un-necessary and also too outlandish an idea.

The notion of M-matrix

1. The most ambitious dream is that zero energy states correspond to a complete solution basis for the Dirac operators associated with WCWs associated with the spaces of CDs with fixed passive boundary: this would define an S-matrix assignable to SFR. Also the analog of S-matrix for the localizations of the states to the active boundary assignable to the BSFR changing the state at the passive boundary of CD is needed.
2. If one allows entanglement between positive and negative energy parts of the zero energy state but assumes that the states at the passive boundary are fixed, one must introduce the counterpart of the density matrix, or rather its square root. This classical free field theory would dictate what I have called M-matrices defined between positive and negative energy parts of zero energy states which form orthonormal rows of what I call U-matrix as a matrix defined between zero energy states. A given M-matrix in turn would decompose to a product of a hermitian square root of density matrix and unitary S-matrix.
3. M-matrix would define time-like entanglement coefficients between positive and negative energy parts of zero energy states (all net quantum numbers vanish for them) and can be regarded as a hermitian square root of density matrix multiplied by a unitary S-matrix. Quantum theory would be in a well-defined sense a square root of thermodynamics. The orthogonality and hermiticity of the M-matrices commuting with S-matrix means that they span infinite-dimensional Lie algebras acting as symmetries of the S-matrix. Therefore quantum TGD would reduce to group theory in a well-defined sense.
4. In fact the Lie algebra of Hermitian M-matrices extends to Kac-Moody type algebra obtained by multiplying hermitian square roots of density matrices with powers of the S-matrix. Also the analog of Yangian algebra involving only non-negative powers of S-matrix is possible and would correspond to a hierarchy of CDs with the temporal distances between tips coming as integer multiples of the CP_2 time.

The M-matrices associated with CDs are obtained by a discrete scaling from the minimal CD and characterized by integer n are naturally proportional to a representation matrix of scaling: $S(n) = S^n$, where S is unitary S-matrix associated with the minimal CD [K77]. This conforms with the idea about unitary time evolution as exponent of Hamiltonian discretized to integer power of S and represented as scaling with respect to the logarithm of the proper time distance between the tips of CD.

5. I have also considered the notion of U-matrix. U-matrix elements between M-matrices for various CDs are proportional to the inner products $Tr[S^{-n_1} \circ H^i H^j \circ S^{n_2} \lambda]$, where λ represents unitarily the discrete Lorentz boost relating the moduli of the active boundary of CD and H^i form an orthonormal basis of Hermitian square roots of density matrices. \circ tells that S acts at the active boundary of CD only. I have proposed a general representation for the U-matrix, reducing its construction to that of the S-matrix.

1.1.6 TGD as a generalized number theory

Quantum T(opological)D(ynamics) as a classical spinor geometry for infinite-dimensional configuration space ("world of classical worlds", WCW), p-adic numbers and quantum TGD, and TGD inspired theory of consciousness, have been for last ten years the basic three strongly interacting threads in the tapestry of quantum TGD. The fourth thread deserves the name "TGD as a generalized number theory". It involves three separate threads: the fusion of real and various p-adic physics to a single coherent whole by requiring number theoretic universality discussed already, the formulation of quantum TGD in terms of complexified counterparts of classical number fields, and the notion of infinite prime. Note that one can identify subrings such as hyper-quaternions and hyper-octonions as sub-spaces of complexified classical number fields with Minkowskian signature of the metric defined by the complexified inner product.

The Threads in the Development of Quantum TGD

The development of TGD has involved several strongly interacting threads: physics as infinite-dimensional geometry; TGD as a generalized number theory, the hierarchy of Planck constants interpreted in terms of dark matter hierarchy, and TGD inspired theory of consciousness. In the following these threads are briefly described.

1. Quantum T(opological) G(eometro)D(ynamics) as a classical spinor geometry for infinite-dimensional WCW, p-adic numbers and quantum TGD, and TGD inspired theory of consciousness and of quantum biology have been for last decade of the second millenium the basic three strongly interacting threads in the tapestry of quantum TGD.
2. The discussions with Tony Smith initiated a fourth thread which deserves the name “TGD as a generalized number theory”. The basic observation was that classical number fields might allow a deeper formulation of quantum TGD. The work with Riemann hypothesis made time ripe for realization that the notion of infinite primes could provide, not only a reformulation, but a deep generalization of quantum TGD. This led to a thorough and rather fruitful revision of the basic views about what the final form and physical content of quantum TGD might be. Together with the vision about the fusion of p-adic and real physics to a larger coherent structure these sub-threads fused to the “physics as generalized number theory” thread.
3. A further thread emerged from the realization that by quantum classical correspondence TGD predicts an infinite hierarchy of macroscopic quantum systems with increasing sizes, that it is not at all clear whether standard quantum mechanics can accommodate this hierarchy, and that a dynamical quantized Planck constant might be necessary and strongly suggested by the failure of strict determinism for the fundamental variational principle. The identification of hierarchy of Planck constants labelling phases of dark matter would be natural. This also led to a solution of a long standing puzzle: what is the proper interpretation of the predicted fractal hierarchy of long ranged classical electro-weak and color gauge fields. Quantum classical correspondences allows only single answer: there is infinite hierarchy of p-adically scaled up variants of standard model physics and for each of them also dark hierarchy. Thus TGD Universe would be fractal in very abstract and deep sense.

The chronology based identification of the threads is quite natural but not logical and it is much more logical to see p-adic physics, the ideas related to classical number fields, and infinite primes as sub-threads of a thread which might be called “physics as a generalized number theory”. In the following I adopt this view. This reduces the number of threads to three corresponding to geometric, number theoretic and topological views of physics.

TGD forces the generalization of physics to a quantum theory of consciousness, and TGD as a generalized number theory vision leads naturally to the emergence of p-adic physics as physics of cognitive representations.

Number theoretic vision very briefly

Number theoretic vision about quantum TGD involves notions like adelic physics, $M^8 - H$ duality and number theoretic universality. A short review of the basic ideas that have developed during years is in order.

1. The physical interpretation of M^8 is as an analog of momentum space and $M^8 - H$ duality is analogous to momentum-position duality of ordinary wave mechanics.
2. Adelic physics means that all classical number fields, all p-adic number fields and their extensions induced by extensions of rationals and defining adeles, and also finite number fields are basic mathematical building bricks of physics.

The complexification of M^8 , identified as complexified octonions, would provide a realization of this picture and $M^8 - H$ duality would map the algebraic physics in M^8 to the ordinary physics in $M^4 \times CP_2$ described in terms of partial differential equations.

3. Negentropy Maximization Principle (NMP) states that the conscious information assignable with cognition representable measured in terms of p-adic negentropy increases in statistical sense.

NMP is mathematically completely analogous to the second law of thermodynamics and number theoretic evolution as an unavoidable statistical increase of the dimension of the algebraic extension of rationals characterizing a given space-time region implies it. There is no paradox involved: the p-adic negentropy measures the conscious information assignable to the entanglement of two systems regarded as a conscious entity whereas ordinary entropy measures the lack of information about the quantum state of either entangled system.

4. Number theoretical universality requires that space-time surfaces or at least their $M^8 - H$ duals in M_c^8 are defined for both reals and various p-adic number fields. This is true if they are defined by polynomials with integer coefficients as surfaces in M^8 obeying number theoretic holography realized as associativity of the normal space of 4-D surface using as holographic data 3-surfaces at mass shells identified in terms of roots of a polynomial. A physically motivated additional condition is that the coefficients of the polynomials are smaller than their degrees.
5. Galois confinement is a key piece of the number theoretic vision. It states that the momenta of physical states are algebraic integers in the extensions of rationals assignable to the space-time region considered. These numbers are in general complex and are not consistent with particle in box quantization. The proposal is that physical states satisfy Galois confinement being thus Galois singlets and having therefore total momenta, whose components are ordinary integers, when momentum unit defined by the scale of causal diamond (CD) is used.
6. The notion of p-adic prime was introduced in p-adic mass calculations that started the developments around 1995. p-Adic length scale hypothesis states that p-adic primes near powers of 2 have a special physical role (as possibly also the powers of other small primes such as $p = 3$).

The proposal is that p-adic primes correspond to ramified primes assignable to the extension and identified as divisors of the polynomial defined by the products of the root differences for the roots of the polynomial defining space-time space and having interpretation as values of, in general complex, virtual mass squared.

p-Adic TGD and fusion of real and p-adic physics to single coherent whole

The p-adic thread emerged for roughly ten years ago as a dim hunch that p-adic numbers might be important for TGD. Experimentation with p-adic numbers led to the notion of canonical identification mapping reals to p-adics and vice versa. The breakthrough came with the successful p-adic mass calculations using p-adic thermodynamics for Super-Virasoro representations with the super-Kac-Moody algebra associated with a Lie-group containing standard model gauge group. Although the details of the calculations have varied from year to year, it was clear that p-adic physics reduces not only the ratio of proton and Planck mass, the great mystery number of physics, but all elementary particle mass scales, to number theory if one assumes that primes near prime powers of two are in a physically favored position. Why this is the case, became one of the key puzzles and led to a number of arguments with a common gist: evolution is present already at the elementary particle level and the primes allowed by the p-adic length scale hypothesis are the fittest ones.

It became very soon clear that p-adic topology is not something emerging in Planck length scale as often believed, but that there is an infinite hierarchy of p-adic physics characterized by p-adic length scales varying to even cosmological length scales. The idea about the connection of p-adics with cognition motivated already the first attempts to understand the role of the p-adics and inspired "Universe as Computer" vision but time was not ripe to develop this idea to anything concrete (p-adic numbers are however in a central role in TGD inspired theory of consciousness). It became however obvious that the p-adic length scale hierarchy somehow corresponds to a hierarchy of intelligences and that p-adic prime serves as a kind of intelligence quotient. Ironically, the almost obvious idea about p-adic regions as cognitive regions of space-time providing cognitive representations for real regions had to wait for almost a decade for the access into my consciousness.

In string model context one tries to reduce the physics to Planck scale. The price is the inability to say anything about physics in long length scales. In TGD p-adic physics takes care of this shortcoming by predicting the physics also in long length scales.

There were many interpretational and technical questions crying for a definite answer.

1. What is the relationship of p-adic non-determinism to the classical non-determinism of the basic field equations of TGD? Are the p-adic space-time region genuinely p-adic or does p-adic topology only serve as an effective topology? If p-adic physics is direct image of real physics, how the mapping relating them is constructed so that it respects various symmetries? Is the basic physics p-adic or real (also real TGD seems to be free of divergences) or both? If it is both, how should one glue the physics in different number field together to get *the* Physics? Should one perform p-adicization also at the level of the WCW? Certainly the p-adicization at the level of super-conformal representation is necessary for the p-adic mass calculations.
2. Perhaps the most basic and most irritating technical problem was how to precisely define p-adic definite integral which is a crucial element of any variational principle based formulation of the field equations. Here the frustration was not due to the lack of solution but due to the too large number of solutions to the problem, a clear symptom for the sad fact that clever inventions rather than real discoveries might be in question. Quite recently I however learned that the problem of making sense about p-adic integration has been for decades central problem in the frontier of mathematics and a lot of profound work has been done along same intuitive lines as I have proceeded in TGD framework. The basic idea is certainly the notion of algebraic continuation from the world of rationals belonging to the intersection of real world and various p-adic worlds.

Despite various uncertainties, the number of the applications of the poorly defined p-adic physics has grown steadily and the applications turned out to be relatively stable so that it was clear that the solution to these problems must exist. It became only gradually clear that the solution of the problems might require going down to a deeper level than that represented by reals and p-adics.

The key challenge is to fuse various p-adic physics and real physics to single larger structure. This has inspired a proposal for a generalization of the notion of number field by fusing real numbers and various p-adic number fields and their extensions along rationals and possible common algebraic numbers. This leads to a generalization of the notions of embedding space and space-time concept and one can speak about real and p-adic space-time sheets. One can talk about adelic space-time, embedding space, and WCW.

The corresponds of real 4-surfaces with the p-adic ones is induced by number theoretical discretization using points of 4-surfaces $Y^4 \subset M_c^8$ identifiable as 8-momenta, whose components are assumed to be algebraic integers in an extension of rationals defined by the extension of rationals associated with a polynomial P with integer coefficients smaller than the degree of P . These points define a cognitive representation, which is universal in the sense that it exists also in the algebraic extensions of p-adic numbers. The points of the cognitive representations associated with the mass shells with mass squared values identified as roots of P are enough since $M^8 - H$ duality can be used at both M^8 and H sides and also in the p-adic context. The mass shells are special in that they allow for Minkowski coordinates very large cognitive representations unlike the interiors of the 4-surfaces determined by holography by using the data defined by the 3-surfaces at the mass shells. The higher the dimension of the algebraic extension associated with P , the better the accuracy of the cognitive representation.

Adelization providing number theoretical universality reduces to algebraic continuation for the amplitudes from this intersection of reality and various p-adicities - analogous to a back of a book - to various number fields. There are no problems with symmetries but canonical identification is needed: various group invariant of the amplitude are mapped by canonical identification to various p-adic number fields. This is nothing but a generalization of the mapping of the p-adic mass squared to its real counterpart in p-adic mass calculations.

This leads to surprisingly detailed predictions and far reaching conjectures. For instance, the number theoretic generalization of entropy concept allows negentropic entanglement central for the applications to living matter (see **Fig.** <http://tgdtheory.fi/appfigures/cat.jpg> or **Fig. ??** in the appendix of this book). One can also understand how preferred p-adic primes could

emerge as so called ramified primes of algebraic extension of rationals in question and characterizing string world sheets and partonic 2-surfaces. Preferred p-adic primes would be ramified primes for extensions for which the number of p-adic continuations of two-surfaces to space-time surfaces (imaginings) allowing also real continuation (realization of imagination) would be especially large. These ramifications would be winners in the fight for number theoretical survival. Also a generalization of p-adic length scale hypothesis emerges from NMP [K73].

The characteristic non-determinism of the p-adic differential equations suggests strongly that p-adic regions correspond to “mind stuff”, the regions of space-time where cognitive representations reside. This interpretation implies that p-adic physics is physics of cognition. Since Nature is probably a brilliant simulator of Nature, the natural idea is to study the p-adic physics of the cognitive representations to derive information about the real physics. This view encouraged by TGD inspired theory of consciousness clarifies difficult interpretational issues and provides a clear interpretation for the predictions of p-adic physics.

Infinite primes

The discovery of the hierarchy of infinite primes and their correspondence with a hierarchy defined by a repeatedly second quantized arithmetic quantum field theory gave a further boost for the speculations about TGD as a generalized number theory.

After the realization that infinite primes can be mapped to polynomials possibly representable as surfaces geometrically, it was clear how TGD might be formulated as a generalized number theory with infinite primes forming the bridge between classical and quantum such that real numbers, p-adic numbers, and various generalizations of p-adics emerge dynamically from algebraic physics as various completions of the algebraic extensions of complexified quaternions and octonions. Complete algebraic, topological and dimensional democracy would characterize the theory.

The infinite primes at the first level of hierarchy, which represent analogs of bound states, can be mapped to irreducible polynomials, which in turn characterize the algebraic extensions of rationals defining a hierarchy of algebraic physics continuable to real and p-adic number fields. The products of infinite primes in turn define more general algebraic extensions of rationals. The interesting question concerns the physical interpretation of the higher levels in the hierarchy of infinite primes and integers mappable to polynomials of $n > 1$ variables.

1.1.7 An explicit formula for $M^8 - H$ duality

$M^8 - H$ duality is a generalization of momentum-position duality relating the number theoretic and geometric views of physics in TGD and, despite that it still involves poorly understood aspects, it has become a fundamental building block of TGD. One has 4-D surfaces $Y^4 \subset M_c^8$, where M_c^8 is complexified M^8 having interpretation as an analog of complex momentum space and 4-D spacetime surfaces $X^4 \subset H = M^4 \times CP_2$. M_c^8 , equivalently E_c^8 , can be regarded as complexified octonions. M_c^8 has a subspace M_c^4 containing M^4 .

Comment: One should be very cautious with the meaning of “complex”. Complexified octonions involve a complex imaginary unit i commuting with the octonionic imaginary units I_k . i is assumed to also appear as an imaginary unit also in complex algebraic numbers defined by the roots of polynomials P defining holographic data in M_c^8 .

In the following $M^8 - H$ duality and its twistor lift are discussed and an explicit formula for the dualities are deduced. Also possible variants of the duality are discussed.

Holography in H

$X^4 \subset H$ satisfies holography and is analogous to the Bohr orbit of a particle identified as a 3-surface. The proposal is that holography reduces to a 4-D generalization of holomorphy so that X^4 is a simultaneous zero of two functions of complex CP_2 coordinates and of what I have called Hamilton-Jacobi coordinates of M^4 with a generalized Kähler structure.

The simplest choice of the Hamilton-Jacobi coordinates is defined by the decomposition $M^4 = M^2 \times E^2$, where M^2 is endowed with hypercomplex structure defined by light-like coordinates (u, v) , which are analogous to z and \bar{z} . Any analytic map $u \rightarrow f(u)$ defines a new set

of light-like coordinates and corresponds to a solution of the massless d'Alembert equation in M^2 . E^2 has some complex coordinates with imaginary unit defined by i .

The conjecture is that also more general Hamilton-Jacobi structures for which the tangent space decomposition is local are possible. Therefore one would have $M^4 = M^2(x) \times E^2(x)$. These would correspond to non-equivalent complex and Kähler structures of M^4 analogous to those possessed by 2-D Riemann surfaces and parametrized by moduli space.

Number theoretic holography in M_c^8

$Y^4 \subset M_c^8$ satisfies number theoretic holography defining dynamics, which should reduce to associativity in some sense. The Euclidian complexified normal space $N^4(y)$ at a given point y of Y^4 is required to be associative, i.e. quaternionic. Besides this, $N^4(i)$ contains a preferred complex Euclidian 2-D subspace $Y^2(y)$. Also the spaces $Y^2(x)$ define an integrable distribution. I have assumed that $Y^2(x)$ can depend on the point y of Y^4 .

These assumptions imply that the normal space $N(y)$ of Y^4 can be parameterized by a point of $CP_2 = SU(3)/U(2)$. This distribution is always integrable unlike quaternionic tangent space distributions. $M^8 - H$ duality assigns to the normal space $N(y)$ a point of CP_2 . M_c^4 point y is mapped to a point $x \in M^4 \subset M^4 \times CP_2$ defined by the real part of its inversion (conformal transformation): this formula involves effective Planck constant for dimensional reasons.

The 3-D holographic data, which partially fixes 4-surfaces Y^4 is partially determined by a polynomial P with real integer coefficients smaller than the degree of P . The roots define mass squared values which are in general complex algebraic numbers and define complex analogs of mass shells in $M_c^4 \subset M_c^8$, which are analogs of hyperbolic spaces H^3 . The 3-surfaces at these mass shells define 3-D holographic data continued to a surface Y^4 by requiring that the normal space of Y^4 is associative, i.e. quaternionic. These 3-surfaces are not completely fixed but an interesting conjecture is that they correspond to fundamental domains of tessellations of H^3 .

What does the complexity of the mass shells mean? The simplest interpretation is that the space-like M^4 coordinates (3-momentum components) are real whereas the time-like coordinate (energy) is complex and determined by the mass shell condition. One would have $Re^2(E) - Im(E)^2 - p^2 = Re(m^2)$ and $2Re(E)Im(E) = Im(m^2)$. The condition for the real parts gives H^3 when $\sqrt{Re^2(E) - Im(E)^2}$ is taken as a time coordinate. The second condition allows to solve $Im(E)$ in terms of $Re(E)$ so that the first condition reduces to an equation of mass shell when $\sqrt{(Re(E)^2 - Im(E)^2)}$, expressed in terms of $Re(E)$, is taken as new energy coordinate $E_{eff} = \sqrt{(Re(E)^2 - Im(E)^2)}$. Is this deformation of H^3 in imaginary time direction equivalent with a region of the hyperbolic 3-space H^3 ?

One can look at the formula in more detail. Mass shell condition gives $Re^2(E) - Im(E)^2 - p^2 = Re(m^2)$ and $2Re(E)Im(E) = Im(m^2)$. The condition for the real parts gives H^3 , when $\sqrt{Re^2(E) - Im(E)^2}$ is taken as an effective energy. The second condition allows to solve $Im(E)$ in terms of $Re(E)$ so that the first condition reduces to a dispersion relation for $Re(E)^2$.

$$Re(E)^2 = \frac{1}{2}(Re(m^2) - Im(m^2) + p^2)(1 \pm \sqrt{1 + \frac{2Im(m^2)^2}{(Re(m^2) - Im(m^2) + p^2)^2}}) \quad (1.1.1)$$

Only the positive root gives a non-tachyonic result for $Re(m^2) - Im(m^2) > 0$. For real roots with $Im(m^2) = 0$ and at the high momentum limit the formula coincides with the standard formula. For $Re(m^2) = Im(m^2)$ one obtains $Re(E)^2 \rightarrow Im(m^2)/\sqrt{2}$ at the low momentum limit $p^2 \rightarrow 0$. Energy does not depend on momentum at all: the situation resembles that for plasma waves.

Can one find an explicit formula for $M^8 - H$ duality?

The dream is an explicit formula for the $M^8 - H$ duality mapping $Y^4 \subset M_c^8$ to $X^4 \subset H$. This formula should be consistent with the assumption that the generalized holomorphy holds true for X^4 .

The following proposal is a more detailed variant of the earlier proposal for which Y^4 is determined by a map g of $M_c^4 \rightarrow SU(3)_c \subset G_{2,c}$, where $G_{2,c}$ is the complexified automorphism group of octonions and $SU(3)_c$ is interpreted as a complexified color group.

This map defines a trivial $SU(3)_c$ gauge field. The real part of g however defines a non-trivial real color gauge field by the non-linearity of the non-abelian gauge field with respect to the gauge potential. The quadratic terms involving the imaginary part of the gauge potential give an additional condition to the real part in the complex situation and cancel it. If only the real part of g contributes, this contribution would be absent and the gauge field is non-vanishing.

How could the automorphism $g(x) \in SU(3) \subset G_2$ give rise to $M^8 - H$ duality?

1. The interpretation is that $g(y)$ at given point y of Y^4 relates the normal space at y to a fixed quaternionic/associative normal space at point y_0 , which corresponds is fixed by some subgroup $U(2)_0 \subset SU(3)$. The automorphism property of g guarantees that the normal space is quaternionic/associative at y . This simplifies the construction dramatically.
2. The quaternionic normal sub-space (which has Euclidian signature) contains a complex sub-space which corresponds to a point of sphere $S^2 = SO(3)/O(2)$, where $SO(3)$ is the quaternionic automorphism group. The interpretation could be in terms of a selection of spin quantization axes. The local choice of the preferred complex plane would not be unique and is analogous to the possibility of having non-trivial Hamilton Jacobi structures in M^4 characterized by the choice of $M^2(x)$ and equivalently its normal subspace $E^2(x)$.

These two structures are independent apart from dependencies forced by the number theoretic dynamics. Hamilton-Jacobi structure means a selection of the quantization axis of spin and energy by fixing a distribution of light-like tangent vectors of M^4 and the choice of the quaternionic normal sub-space fixes a choice of preferred quaternionic imaginary unit defining a quantization axis of the weak isospin.

3. The real part $Re(g(y))$ defines a point of $SU(3)$ and the bundle projection $SU(3) \rightarrow CP_2$ in turn defines a point of $CP_2 = SU(3)/U(2)$. Hence one can assign to g a point of CP_2 as $M^8 - H$ duality requires and deduce an explicit formula for the point. This means a realization of the dream.
4. The construction requires a fixing of a quaternionic normal space N_0 at y_0 containing a preferred complex subspace at a single point of Y^4 plus a selection of the function g . If M^4 coordinates are possible for Y^4 , the first guess is that g as a function of complexified M^4 coordinates obeys generalized holomorphy with respect to complexified M^4 coordinates in the same sense and in the case of X^4 . This might guarantee that the $M^8 - H$ image of Y^4 satisfies the generalized holomorphy.
5. Also space-time surfaces X^4 with M^4 projection having a dimension smaller than 4 are allowed. I have proposed that they might correspond to singular cases for the above formula: a kind of blow-up would be involved. One can also consider a more general definition of Y^4 allowing it to have a M^4 projection with dimension smaller than 4 (say cosmic strings). Could one have implicit equations for the surface Y^4 in terms of the complex coordinates of $SU(3)_c$ and M^4 ? Could this give for instance cosmic strings with a 2-D M^4 projection and CP_2 type extremals with 4-D CP_2 projection and 1-D light-like M^4 projection?

What could the number theoretic holography mean physically?

What could be physical meaning of the number theoretic holography? The condition that has been assumed is that the CP_2 coordinates at the mass shells of $M_c^4 \subset M_c^8$ mapped to mass shells H^3 of $M^4 \subset M^4 \times CP_2$ are constant at the H^3 . This is true if the $g(y)$ defines the same CP_2 point for a given component X_i^3 of the 3-surface at a given mass shell. g is therefore fixed apart from a local $U(2)$ transformation leaving the CP_2 point invariant. A stronger condition would be that the CP_2 point is the same for each component of X_i^3 and even at each mass shell but this condition seems to be unnecessarily strong.

Comment: One can criticize this condition as too strong and one can consider giving up this condition. The motivation for this condition is that the number of algebraic points at the 3-surfaces associated with H^3 explodes since the coordinates associated with normal directions vanish. Kind of cognitive explosion would be in question.

$SU(3)$ corresponds to a subgroup of G_2 and one can wonder what the fixing of this subgroup could mean physically. G_2 is 14-D and the coset space $G_2/SU(3)$ is 6-D and a good guess is that

it is just the 6-D twistor space $SU(3)/U(1) \times U(1)$ of CP_2 : at least the isometries are the same. The fixing of the $SU(3)$ subgroup means fixing of a CP_2 twistor. Physically this means the fixing of the quantization axis of color isospin and hypercharge.

Twistor lift of the holography

What is interesting is that by replacing $SU(3)$ with G_2 , one obtains an explicit formula from the generalization of $M^8 - H$ duality to that for the twistorial lift of TGD!

One can also consider a twistorial generalization of the above proposal for the number theoretic holography by allowing local G_2 automorphisms interpreted as local choices of the color quantization axis. G_2 elements would be fixed apart from a local $SU(3)$ transformation at the components of 3-surfaces at mass shells. The choice of the color quantization axes for a connected 3-surface at a given mass shell would be the same everywhere. This choice is indeed very natural physically since 3-surface corresponds to a particle.

Is this proposal consistent with the boundary condition of the number theoretical holography mean in the case of 4-surfaces in M_c^8 and $M^4 \times CP_2$?

1. The selection of $SU(3) \subset G_2$ for ordinary $M^8 - H$ duality means that the $G_{2,c}$ gauge field vanishes everywhere and the choice of color quantization axis is the same at all points of the 4-surface. The fixing of the CP_2 point to be constant at H^3 implies that the color gauge field at $H^3 \subset M_c^8$ and its image $H^3 \subset H$ vanish. One would have color confinement at the mass shells H_i^3 , where the observations are made. Is this condition too strong?
2. The constancy of the G_2 element at mass shells makes sense physically and means a fixed color quantization axis. The selection of a fixed $SU(3) \subset G_2$ for entire space-time surface is in conflict with the non-constancy of G_2 element unless G_2 element differs at different points of 4-surface only by a multiplication of a local $SU(3)_0$ element, that is local $SU(3)$ transformation. This kind of variation of the G_2 element would mean a fixed color group but varying choice of color quantization axis.
3. Could one consider the possibility that the local $G_{2,c}$ element is free and defines the twistor lift of $M^8 - H$ duality as something more fundamental than the ordinary $M^8 - H$ duality based on $SU(3)_c$. This duality would make sense only at the mass shells so that only the spaces $H^3 \times CP_2$ assignable to mass shells would make sense physically? In the interior CP_2 would be replaced with the twistor space $SU(3)/U(1) \times U(1)$. Color gauge fields would be non-vanishing at the mass shells but outside the mass shells one would have G_2 gauge fields.

There is also a physical objection against the G_2 option. The 14-D Lie algebra representation of G_2 acts on the imaginary octonions which decompose with respect to the color group to $1 \oplus 3 \oplus \bar{3}$. The automorphism property requires that 1 can be transformed to 3 or $\bar{3}$ to themselves: this requires that the decomposition contains $3 \oplus \bar{3}$. Furthermore, it must be possible to transform 3 and $\bar{3}$ to themselves, which requires the presence of 8. This leaves only the decomposition $8 \oplus 3 \oplus \bar{3}$. G_2 gluons would both color octet and triplets. In the TDG framework the only conceivable interpretation would be in terms of ordinary gluons and leptoquark-like gluons. This does not fit with the basic vision of TGD.

The choice of twistor as a selection of quantization axes should make sense also in the M^4 degrees of freedom. M^4 twistor corresponds to a choice of light-like direction at a given point of M^4 . The spatial component of the light-like vector fixes the spin quantization axis. Its choice together with the light-likeness fixes the time direction and therefore the rest system and energy quantization axis. Light-like vector fixes also the choice of M^2 and of E^2 as its orthogonal complement. Therefore the fixing of M^4 twistor as a point of $SU(4)/SU(3) \times U(1)$ corresponds to a choice of the spin quantization axis and the time-like axis defining the rest system in which the energy is measured. This choice would naturally correspond to the Hamilton-Jacobi structure fixing the decompositions $M^2(x) \times E^2(x)$. At a given mass shell the choice of the quantization axis would be constant for a given X_i^3 .

1.1.8 Hierarchy of Planck Constants and Dark Matter Hierarchy

By quantum classical correspondence space-time sheets can be identified as quantum coherence regions. Hence the fact that they have all possible size scales more or less unavoidably implies that Planck constant must be quantized and have arbitrarily large values. If one accepts this then also the idea about dark matter as a macroscopic quantum phase characterized by an arbitrarily large value of Planck constant emerges naturally as does also the interpretation for the long ranged classical electro-weak and color fields predicted by TGD. Rather seldom the evolution of ideas follows simple linear logic, and this was the case also now. In any case, this vision represents the fifth, relatively new thread in the evolution of TGD and the ideas involved are still evolving.

Dark Matter as Large \hbar Phases

D. Da Rocha and Laurent Nottale [E2] have proposed that Schrödinger equation with Planck constant \hbar replaced with what might be called gravitational Planck constant $\hbar_{gr} = \frac{GmM}{v_0}$ ($\hbar = c = 1$). v_0 is a velocity parameter having the value $v_0 = 144.7 \pm .7$ km/s giving $v_0/c = 4.6 \times 10^{-4}$. This is rather near to the peak orbital velocity of stars in galactic halos. Also subharmonics and harmonics of v_0 seem to appear. The support for the hypothesis coming from empirical data is impressive.

Nottale and Da Rocha believe that their Schrödinger equation results from a fractal hydrodynamics. Many-sheeted space-time however suggests that astrophysical systems are at some levels of the hierarchy of space-time sheets macroscopic quantum systems. The space-time sheets in question would carry dark matter.

Nottale's hypothesis would predict a gigantic value of \hbar_{gr} . Equivalence Principle and the independence of gravitational Compton length on mass m implies however that one can restrict the values of mass m to masses of microscopic objects so that \hbar_{gr} would be much smaller. Large \hbar_{gr} could provide a solution of the black hole collapse (IR catastrophe) problem encountered at the classical level. The resolution of the problem inspired by TGD inspired theory of living matter is that it is the dark matter at larger space-time sheets which is quantum coherent in the required time scale [K111].

It is natural to assign the values of Planck constants postulated by Nottale to the space-time sheets mediating gravitational interaction and identifiable as magnetic flux tubes (quanta) possibly carrying monopole flux and identifiable as remnants of cosmic string phase of primordial cosmology. The magnetic energy of these flux quanta would correspond to dark energy and magnetic tension would give rise to negative "pressure" forcing accelerate cosmological expansion. This leads to a rather detailed vision about the evolution of stars and galaxies identified as bubbles of ordinary and dark matter inside magnetic flux tubes identifiable as dark energy.

Certain experimental findings suggest the identification $\hbar_{eff} = n \times \hbar_{gr}$. The large value of \hbar_{gr} can be seen as a way to reduce the string tension of fermionic strings so that gravitational (in fact all!) bound states can be described in terms of strings connecting the partonic 2-surfaces defining particles (analogous to AdS/CFT description). The values $\hbar_{eff}/\hbar = n$ can be interpreted in terms of a hierarchy of breakings of super-conformal symmetry in which the super-conformal generators act as gauge symmetries only for a sub-algebras with conformal weights coming as multiples of n . Macroscopic quantum coherence in astrophysical scales is implied. If also Kähler-Dirac action is present, part of the interior degrees of freedom associated with the Kähler-Dirac part of conformal algebra become physical. A possible is that fermionic oscillator operators generate super-symmetries and sparticles correspond almost by definition to dark matter with $\hbar_{eff}/\hbar = n > 1$. One implication would be that at least part if not all gravitons would be dark and be observed only through their decays to ordinary high frequency graviton ($E = \hbar f_{high} = \hbar_{eff} f_{low}$) of bunch of n low energy gravitons.

Hierarchy of Planck Constants from the Anomalies of Neuroscience and Biology

The quantal ELF effects of ELF em fields on vertebrate brain have been known since seventies. ELF em fields at frequencies identifiable as cyclotron frequencies in magnetic field whose intensity is about 2/5 times that of Earth for biologically important ions have physiological effects and affect also behavior. What is intriguing that the effects are found only in vertebrates (to my best knowledge). The energies for the photons of ELF em fields are extremely low - about 10^{-10} times

lower than thermal energy at physiological temperatures- so that quantal effects are impossible in the framework of standard quantum theory. The values of Planck constant would be in these situations large but not gigantic.

This inspired the hypothesis that these photons correspond to so large a value of Planck constant that the energy of photons is above the thermal energy. The proposed interpretation was as dark photons and the general hypothesis was that dark matter corresponds to ordinary matter with non-standard value of Planck constant. If only particles with the same value of Planck constant can appear in the same vertex of Feynman diagram, the phases with different value of Planck constant are dark relative to each other. The phase transitions changing Planck constant can however make possible interactions between phases with different Planck constant but these interactions do not manifest themselves in particle physics. Also the interactions mediated by classical fields should be possible. Dark matter would not be so dark as we have used to believe.

The hypothesis $h_{eff} = h_{gr}$ - at least for microscopic particles - implies that cyclotron energies of charged particles do not depend on the mass of the particle and their spectrum is thus universal although corresponding frequencies depend on mass. In bio-applications this spectrum would correspond to the energy spectrum of bio-photons assumed to result from dark photons by h_{eff} reducing phase transition and the energies of bio-photons would be in visible and UV range associated with the excitations of bio-molecules.

Also the anomalies of biology (see for instance [K93, K94, K91]) support the view that dark matter might be a key player in living matter.

Dark Matter as a Source of Long Ranged Weak and Color Fields

Long ranged classical electro-weak and color gauge fields are unavoidable in TGD framework. The smallness of the parity breaking effects in hadronic, nuclear, and atomic length scales does not however seem to allow long ranged electro-weak gauge fields. The problem disappears if long range classical electro-weak gauge fields are identified as space-time correlates for massless gauge fields created by dark matter. Also scaled up variants of ordinary electro-weak particle spectra are possible. The identification explains chiral selection in living matter and unbroken $U(2)_{ew}$ invariance and free color in bio length scales become characteristics of living matter and of bio-chemistry and bio-nuclear physics.

The recent view about the solutions of Kähler- Dirac action assumes that the modes have a well-defined em charge and this implies that localization of the modes to 2-D surfaces (right-handed neutrino is an exception). Classical W boson fields vanish at these surfaces and also classical Z^0 field can vanish. The latter would guarantee the absence of large parity breaking effects above intermediate boson scale scaling like h_{eff} .

1.1.9 Twistors in TGD and connection with Veneziano duality

The twistorialization of TGD has two aspects. The attempt to generalize twistor Grassmannian approach emerged first. It was however followed by the realization that also the twistor lift of TGD at classical space-time level is needed. It turned out that the progress in the understanding of the classical twistor lift has been much faster - probably this is due to my rather limited technical QFT skills.

Twistor lift at space-time level

8-dimensional generalization of ordinary twistors is highly attractive approach to TGD [K129]. The reason is that M^4 and CP_2 are completely exceptional in the sense that they are the only 4-D manifolds allowing twistor space with Kähler structure [A19]. The twistor space of $M^4 \times CP_2$ is Cartesian product of those of M^4 and CP_2 . The obvious idea is that space-time surfaces allowing twistor structure if they are orientable are representable as surfaces in H such that the properly induced twistor structure coincides with the twistor structure defined by the induced metric.

In fact, it is enough to generalize the induction of spinor structure to that of twistor structure so that the induced twistor structure need not be identical with the ordinary twistor structure possibly assignable to the space-time surface. The induction procedure reduces to a dimensional reduction of 6-D Kähler action giving rise to 6-D surfaces having bundle structure with twistor

sphere as fiber and space-time as base. The twistor sphere of this bundle is imbedded as sphere in the product of twistor spheres of twistor spaces of M^4 and CP_2 .

This condition would define the dynamics, and the original conjecture was that this dynamics is equivalent with the identification of space-time surfaces as preferred extremals of Kähler action. The dynamics of space-time surfaces would be lifted to the dynamics of twistor spaces, which are sphere bundles over space-time surfaces. What is remarkable that the powerful machinery of complex analysis becomes available.

It however turned out that twistor lift of TGD is much more than a mere technical tool. First of all, the dimensionally reduction of 6-D Kähler action contained besides 4-D Kähler action also a volume term having interpretation in terms of cosmological constant. This need not bring anything new, since all known extremals of Kähler action with non-vanishing induced Kähler form are minimal surfaces. There is however a large number of embeddings of twistor sphere of space-time surface to the product of twistor spheres. Cosmological constant has spectrum and depends on length scale, and the proposal is that coupling constant evolution reduces to that for cosmological constant playing the role of cutoff length. That cosmological constant could transform from a mere nuisance to a key element of fundamental physics was something totally new and unexpected.

1. The twistor lift of TGD at space-time level forces to replace 4-D Kähler action with 6-D dimensionally reduced Kähler action for 6-D surface in the 12-D Cartesian product of 6-D twistor spaces of M^4 and CP_2 . The 6-D surface has bundle structure with twistor sphere as fiber and space-time surface as base.

Twistor structure is obtained by inducing the twistor structure of 12-D twistor space using dimensional reduction. The dimensionally reduced 6-D Kähler action is sum of 4-D Kähler action and volume term having interpretation in terms of a dynamical cosmological constant depending on the size scale of space-time surface (or of causal diamond CD in zero energy ontology (ZEO)) and determined by the representation of twistor sphere of space-time surface in the Cartesian product of the twistor spheres of M^4 and CP_2 .

2. The preferred extremal property as a representation of quantum criticality would naturally correspond to minimal surface property meaning that the space-time surface is separately an extremal of both Kähler action and volume term almost everywhere so that there is no coupling between them. This is the case for all known extremals of Kähler action with non-vanishing induced Kähler form.

Minimal surface property could however fail at 2-D string world sheets, their boundaries and perhaps also at partonic 2-surfaces. The failure is realized in minimal sense if the 3-surface has 1-D edges/folds (strings) and 4-surface 2-D edges/folds (string world sheets) at which some partial derivatives of the embedding space coordinates are discontinuous but canonical momentum densities for the entire action are continuous.

There would be no flow of canonical momentum between interior and string world sheet and minimal surface equations would be satisfied for the string world sheet, whose 4-D counterpart in twistor bundle is determined by the analog of 4-D Kähler action. These conditions allow the transfer of canonical momenta between Kähler- and volume degrees of freedom at string world sheets. These no-flow conditions could hold true at least asymptotically (near the boundaries of CD).

$M^8 - H$ duality suggests that string world sheets (partonic 2-surfaces) correspond to images of complex 2-sub-manifolds of M^8 (having tangent (normal) space which is complex 2-plane of octonionic M^8).

3. Cosmological constant would depend on p-adic length scales and one ends up to a concrete model for the evolution of cosmological constant as a function of p-adic length scale and other number theoretic parameters (such as Planck constant as the order of Galois group): this conforms with the earlier picture.

Inflation is replaced with its TGD counterpart in which the thickening of cosmic strings to flux tubes leads to a transformation of Kähler magnetic energy to ordinary and dark matter. Since the increase of volume increases volume energy, this leads rapidly to energy minimum at some flux tube thickness. The reduction of cosmological constant by a phase transition

however leads to a new expansion phase. These jerks would replace smooth cosmic expansion of GRT. The discrete coupling constant evolution predicted by the number theoretical vision could be understood as being induced by that of cosmological constant taking the role of cutoff parameter in QFT picture [L77].

Twistor lift at the level of scattering amplitudes and connection with Veneziano duality

The classical part of twistor lift of TGD is rather well-understood. Concerning the twistorialization at the level of scattering amplitudes the situation is much more difficult conceptually - I already mentioned my limited QFT skills.

1. From the classical picture described above it is clear that one should construct the 8-D twistorial counterpart of theory involving space-time surfaces, string world sheets and their boundaries, plus partonic 2-surfaces and that this should lead to concrete expressions for the scattering amplitudes.

The light-like boundaries of string world sheets as carriers of fermion numbers would correspond to twistors as they appear in twistor Grassmann approach and define the analog for the massless sector of string theories. The attempts to understand twistorialization have been restricted to this sector.

2. The beautiful basic prediction would be that particles massless in 8-D sense can be massive in 4-D sense. Also the infrared cutoff problematic in twistor approach emerges naturally and reduces basically to the dynamical cosmological constant provided by classical twistor lift.

One can assign 4-momentum both to the spinor harmonics of the embedding space representing ground states of super-conformal representations and to light-like boundaries of string world sheets at the orbits of partonic 2-surfaces. The two four-momenta should be identical by quantum classical correspondence: this could be seen as a concretization of Equivalence Principle. Also a connection with string model emerges.

3. As far as symmetries are considered, the picture looks rather clear. Ordinary twistor Grassmannian approach boils down to the construction of scattering amplitudes in terms of Yangian invariants for conformal group of M^4 . Therefore a generalization of super-symplectic symmetries to their Yangian counterpart seems necessary. These symmetries would be gigantic but how to deduce their implications?
4. The notion of positive Grassmannian is central in the twistor approach to the scattering amplitudes in $calN = 4$ SUSYs. TGD provides a possible generalization and number theoretic interpretation of this notion. TGD generalizes the observation that scattering amplitudes in twistor Grassmann approach correspond to representations for permutations. Since 2-vertex is the only fermionic vertex in TGD, OZI rules for fermions generalizes, and scattering amplitudes are representations for braidings.

Braid interpretation encourages the conjecture that non-planar diagrams can be reduced to ordinary ones by a procedure analogous to the construction of braid (knot) invariants by gradual un-braiding (un-knotting).

This is however not the only vision about a solution of non-planarity. Quantum criticality provides different view leading to a totally unexpected connection with string models, actually with the Veneziano duality, which was the starting point of dual resonance model in turn leading via dual resonance models to super string models.

1. Quantum criticality in TGD framework means that coupling constant evolution is discrete in the sense that coupling constants are piecewise constant functions of length scale replaced by dynamical cosmological constant. Loop corrections would vanish identically and the recursion formulas for the scattering amplitudes (allowing only planar diagrams) deduced in twistor Grassmann would involve no loop corrections. In particular, cuts would be replaced by sequences of poles mimicking them like sequences of point charge mimic line charges. In momentum discretization this picture follows automatically.

2. This would make sense in finite measurement resolution realized in number theoretical vision by number-theoretic discretization of the space-time surface (cognitive representation) as points with coordinates in the extension of rationals defining the adele [L56]. Similar discretization would take place for momenta. Loops would vanish at the level of discretization but what would happen at the possibly existing continuum limit: does the sequence of poles integrate to cuts? Or is representation as sum of resonances something much deeper?
3. Maybe it is! The basic idea of behind the original Veneziano amplitudes (see <http://tinyurl.com/yyhwvqb>) was Veneziano duality. This 4-particle amplitude was generalized by Yoshiro Nambu, Holger-Bek Nielsen, and Leonard Susskind to N-particle amplitude (see <http://tinyurl.com/yyvkx7as>) based on string picture, and the resulting model was called dual resonance model. The model was forgotten as QCD emerged. Later came superstring models and led to M-theory. Now it has become clear that something went wrong, and it seems that one must return to the roots. Could the return to the roots mean a careful reconsideration of the dual resonance model?
4. Recall that Veneziano duality (1968) was deduced by assuming that scattering amplitude can be described as sum over s-channel resonances or t-channel Regge exchanges and Veneziano duality stated that hadronic scattering amplitudes have representation as sums over s- or t-channel resonance poles identified as excitations of strings. The sum over exchanges defined by t-channel resonances indeed reduces at larger values of s to Regge form.

The resonances had zero width, which was not consistent with unitarity. Further, there were no counterparts for the *sum* of s-, t-, and u-channel diagrams with continuous cuts in the kinematical regions encountered in QFT approach. What puts bells ringing is the u-channel diagrams would be non-planar and non-planarity is the problem of twistor Grassmann approach.

5. Veneziano duality is true only for s- and t- channels but not been s- and u-channel. Stringy description makes t-channel and s-channel pictures equivalent. Could it be that in fundamental description u-channels diagrams cannot be distinguished from s-channel diagrams or t-channel diagrams? Could the stringy representation of the scattering diagrams make u-channel twist somehow trivial if handles of string world sheet representing stringy loops in turn representing the analog of non-planarity of Feynman diagrams are absent? The permutation of external momenta for tree diagram in absence of loops in planar representation would be a twist of π in the representation of planar diagram as string world sheet and would not change the topology of the string world sheet and would not involve non-trivial world sheet topology.

For string world sheets loops would correspond to handles. The presence of handle would give an edge with a loop at the level of 3-surface (self energy correction in QFT). Handles are not allowed if the induced metric for the string world sheet has Minkowskian signature. If the stringy counterparts of loops are absent, also the loops in scattering amplitudes should be absent.

This argument applies only inside the Minkowskian space-time regions. If string world sheets are present also in Euclidian regions, they might have handles and loop corrections could emerge in this manner. In TGD framework strings (string world sheets) are identified to 1-D edges/folds of 3-surface at which minimal surface property and topological QFT property fails (minimal surfaces as calibrations). Could the interpretation of edge/fold as discontinuity of some partial derivatives exclude loopy edges: perhaps the branching points would be too singular?

A reduction to a sum over s-channel resonances is what the vanishing of loops would suggest. Could the presence of string world sheets make possible the vanishing of continuous cuts even at the continuum limit so that continuum cuts would emerge only in the approximation as the density of resonances is high enough?

The replacement of continuous cut with a sum of *infinitely* narrow resonances is certainly an approximation. Could it be that the stringy representation as a sum of resonances with *finite* width is an essential aspect of quantum physics allowing to get rid of infinities necessarily accompanying loops? Consider now the arguments against this idea.

1. How to get rid of the problems with unitarity caused by the zero width of resonances? Could *finite* resonance widths make unitarity possible? Ordinary twistor Grassmannian approach predicts that the virtual momenta are light-like but complex: obviously, the imaginary part of the energy in rest frame would have interpretation as resonance width.

In TGD framework this generalizes for 8-D momenta. By quantum-classical correspondence (QCC) the classical Noether charges are equal to the eigenvalues of the fermionic charges in Cartan algebra (maximal set of mutually commuting observables) and classical TGD indeed predicts complex momenta (Kähler coupling strength is naturally complex). QCC thus supports this proposal.

2. Sum over resonances/exchanges picture is in conflict with QFT picture about scattering of particles. Could *finite* resonance widths due to the complex momenta give rise to the QFT type scattering amplitudes as one develops the amplitudes in Taylor series with respect to the resonance width? Unitarity condition indeed gives the first estimate for the resonance width.

QFT amplitudes should emerge in an approximation obtained by replacing the discrete set of finite width resonances with a cut as the distance between poles is shorter than the resolution for mass squared.

In superstring models string tension has single very large value and one cannot obtain QFT type behavior at low energies (for instance, scattering amplitudes in hadronic string model are concentrated in forward direction). TGD however predicts an entire hierarchy of p-adic length scales with varying string tension. The hierarchy of mass scales corresponding roughly to the lengths and thickness of magnetic flux tubes as thickened cosmic strings and characterized by the value of cosmological constant predicted by twistor lift of TGD. Could this give rise to continuous QCT type cuts at the limit when measurement resolution cannot distinguish between resonances?

The dominating term in the sum over sums of resonances in t -channel gives near forward direction approximately the lowest mass resonance for strings with the smallest string tension. This gives the behavior $1/(t - m_{min}^2)$, where m_{min} corresponds to the longest mass scale involved (the largest space-time sheet involved), approximating the $1/t$ -behavior of massless theories. This also brings in IR cutoff, the lack of which is a problem of gauge theories. This should give rise to continuous QFT type cuts at the limit when measurement resolution cannot distinguish between resonances.

1.2 TGD As A Generalization Of Physics To A Theory Consciousness

General Coordinate Invariance forces the identification of quantum jump as quantum jump between entire deterministic quantum histories rather than time=constant snapshots of single history. The new view about quantum jump forces a generalization of quantum measurement theory such that observer becomes part of the physical system. The basic idea is that quantum jump can be identified as momentum of consciousness. Thus a general theory of consciousness is unavoidable outcome. This theory is developed in detail in the books [K127, K22, K90, K20, K55, K66, K70, K113, K125].

It is good to list first the basic challenges of TGD inspired theory of consciousness. The challenges can be formulated as questions. Reader can decide how satisfactory the answered proposed by TGD are.

1. What does one mean with quantum jump? Can one overcome the basic problem of the standard quantum measurement theory, that which forcing Bohr to give up totally the idea about objective reality?
2. How do the experienced time and geometric time relate in this framework? How the arrow of subjective time translates to that of geometric time?
3. How to define conscious information? Is it conserved or even increased during time evolution as biological evolution suggests? How does this increase relate to second law implied basically by the randomness of state function reduction?

4. Conscious entities/selves/observers seem to exist. If they are real how do they emerge?

1.2.1 Quantum Jump As A Moment Of Consciousness

The identification of quantum jump between deterministic quantum histories (WCW spinor fields) as a moment of consciousness defines microscopic theory of consciousness. Quantum jump involves the steps

$$\Psi_i \rightarrow U\Psi_i \rightarrow \Psi_f ,$$

where U is informational “time development” operator, which is unitary like the S-matrix characterizing the unitary time evolution of quantum mechanics. U is formally analogous to Schrödinger time evolution of infinite duration. The time evolution can however be interpreted as a sequence of discrete scalings and Lorentz boosts of causal diamond (CD) and the time corresponds to the change of the proper time distance between the tips of CD.

In TGD framework S-matrix is generalized to a triplet of U-, M-, and S-matrices. M-matrix is a hermitian square root of density matrix between positive and negative energy states multiplied by universal S-matrix depending on the scale of CD only. The square roots of projection operators form an orthonormal basis. U-matrix and S-matrix are completely universal objects characterizing the dynamics of evolution by self-organization.

The M-matrices associated with CDs are obtained by a discrete scaling from the minimal CD and characterized by integer n are naturally proportional to S^n , where S is the S-matrix associated with the minimal CD. This conforms with the idea about unitary time evolution as exponent of Hamiltonian discretized to integer power of S .

U-matrix elements between M-matrices for various CDs are proportional to the inner products $\text{Tr}[S^{-n_1} \circ H^i H^j \circ S^{n_2} \lambda]$, where λ represents unitarily the discrete Lorentz boost relating the moduli of the active boundary of CD and H^i form an orthonormal basis of Hermitian square roots of density matrices. \circ tells that S acts at the active boundary of CD only. It turns out possible to construct a general representation for the U-matrix reducing its construction to that of S-matrix.

The requirement that quantum jump corresponds to a measurement in the sense of quantum field theories implies that each quantum jump involves localization in zero modes which parameterize also the possible choices of the quantization axes. Thus the selection of the quantization axes performed by the Cartesian outsider becomes now a part of quantum theory. Together these requirements imply that the final states of quantum jump correspond to quantum superpositions of space-time surfaces which are macroscopically equivalent. Hence the world of conscious experience looks classical. At least formally quantum jump can be interpreted also as a quantum computation in which matrix U represents unitary quantum computation which is however not identifiable as unitary translation in time direction and cannot be “engineered”.

In ZEO U-matrix should correspond relates zero energy states to each other and M matrices defining the rows of U matrix should be assignable to a fixed CD. Zero energy states should have wave function in the moduli space of CDs such that the second boundary of every CD would belong to a boundary of fixed light-cone but second boundary would be free with possible constraint that the distance between the tips of CD is multiple of CP_2 time.

Zero energy states of ZEO correspond in positive energy ontology to physical events and break time reversal invariance. This because either the positive or negative energy part of the state is reduced/equivalently prepared whereas the second end of CD corresponds to a superposition of (negative/positive energy) states with varying particle numbers and single particle quantum numbers just as in ordinary particle physics experiment.

The first state function reduction at given boundary of CD must change the roles of the ends of CDs. This reduction can be followed by a sequence of reductions to the same boundary of CD and not changing the boundary nor the parts of zero energy states associated with it but changing the states at the second end and also quantum distribution of the second boundary in the moduli space of CDs. In standard measurement theory the follow-up reductions would not affect the state at all.

The understanding of how the arrow of time and experience about its flow emerge have been the most difficult problem of TGD inspired theory of consciousness and I have considered several proposals during years having the geometry of future light-cone as the geometric core element.

1. The basic objection is that the arrow of geometric time alternates at embedding space level but we know that arrow of time looks the same in the part of the Universe we live. Possible exceptions however exist, for instance phase conjugate laser beams seem to obey opposite arrow of time. Also biological phenomena might involve non-standard arrow of time at some levels. This led Fantappiè [J92] to introduce the notion of syntropy. This suggests that the arrow of time depends on the size scale of CD and of space-time sheet.
2. It took some time to realize that the solution of the problem is trivial in ZEO. In the ordinary quantum measurement theory one must assume that state function reduction can occur repeatedly: the assumption is that nothing happens to the state during repeated reductions. The outcome is Zeno effect: the watched pot does not boil.

In TGD framework situation is different. Repeated state function reduction leaves the already reduced parts of zero energy state invariant but can change the part of states at the opposite boundary. One must allow a delocalization of the second boundary of CDs and one assumes that the second tip has quantized distance to the fixed one coming as multiple of CP_2 time. Also Lorentz boosts leaving the second CD boundary invariant must be allowed. One must therefore introduce a wave function in the moduli space of CDs with second boundary forming part of fixed light-cone boundary ($\delta M_{\pm}^4 \times CP_2$).

3. The sequence of state function reductions on a fixed boundary of CD leads to the increase of the average temporal distance between the tips of CDs and this gives rise to the experience about flow of time as shifting of contents of perception towards future if the change is what contributes to conscious experience and gives rise to a fixed arrow of time.
4. Contrary to original working hypothesis, state function reduction in the usual sense does not solely determine the ordinary conscious experience. It can however contribute to conscious experience and the act of free will is a good candidate in this respect. TGD view about realization of intentional action assumes that intentional actions involve negative energy signals propagating backwards in geometric time. This would mean that at some level of CD hierarchy the arrow of geometric time indeed changes and the reduction starts to occur at opposite boundary of CD at some level of length scale hierarchy.

1.2.2 Negentropy Maximization Principle (NMP)

Information is the basic aspect of consciousness and this motivates the introduction of Negentropy Maximization Principle (NMP) [K73] as the fundamental variational principle of consciousness theory. The amount of negentropy of zero energy state should increase in each quantum jump. The ordinary entanglement entropy is also non-negative so that negentropy could be at best zero. Since p-adic physics is assumed to be a correlate of cognition, it is natural to generalize Shannon entropy to its number theoretic variant by replacing the probabilities appearing as arguments of logarithms of probabilities with their p-adic norms. This gives negentropy which can be positive so that NMP can generate entanglement.

Consistency with quantum measurement theory allows only negentropic density matrices proportional to unit matrix and negentropy has the largest positive value for the largest power of prime factor of the dimension of density matrix. Entanglement matrix proportional to unitary matrix familiar from quantum computation corresponds to unit density matrix and large $h_{eff} = n \times h$ states are excellent candidates for forming negentropic entanglement (see **Fig. <http://tgdtheory.fi/appfigures/cat.jpg>** or **Fig. ??** in the appendix of this book).

The interpretation of negentropic entanglement is as a rule. The instances of the rule correspond to the pairs appearing in the superposition and the larger the number of pairs is, the higher the abstraction level of the rule is. NMP is not in conflict with the second law since negentropy in the sense of NMP is not single particle property. Ordinary quantum jumps indeed generate entropy at the level of ensemble as also quantum jumps for states for which the density matrix is direct sum of unit matrices with various dimensions.

NMP forces the negentropic entanglement resources of the Universe to grow and thus implies evolution. I have coined the name “Akashic records” for these resources forming something analogous to library. It has turned out that the only viable option is that negentropic entanglement is experienced directly.

1.2.3 The Notion Of Self

The concept of self seems to be absolutely essential for the understanding of the macroscopic and macro-temporal aspects of consciousness and would be counterpart for observer in quantum measurement theory.

1. The original view was that self corresponds to a subsystem able to remain un-entangled under the sequential informational “time evolutions” U . It is however unclear how it could be possible to avoid generation of entanglement.
2. In ZEO the situation changes. Self corresponds to a sequence of quantum jumps for which the parts of zero energy states at either boundary of CD remain unchanged. Therefore one can say that self defined in terms of parts of states assignable to this boundary remains unaffected as sub-system and does not generate entanglement. At the other boundary changes occur and give rise to the experience of time flow and arrow of time since the average temporal distance between the tips of CD tends to increase.

When the reductions begin to occur at the opposite boundary of CD, self “falls asleep”: symmetry suggests that new self living in opposite direction of geometric time is generated. Also in biological the change of time direction at some level of hierarchy might take place.

3. It looks natural to assume that the experiences of the self after the last “wake-up” sum up to single average experience. This means that subjective memory is identifiable as conscious, immediate short term memory. Selves form an infinite hierarchy with the entire Universe at the top. Self can be also interpreted as mental images: our mental images are selves having mental images and also we represent mental images of a higher level self. A natural hypothesis is that self S experiences the experiences of its sub-selves as kind of abstracted experience: the experiences of sub-selves S_i are not experienced as such but represent kind of averages $\langle S_{ij} \rangle$ of sub-sub-selves S_{ij} . Entanglement between selves, most naturally realized by the formation of flux tube bonds between cognitive or material space-time sheets, provides a possible a mechanism for the fusion of selves to larger selves (for instance, the fusion of the mental images representing separate right and left visual fields to single visual field) and forms wholes from parts at the level of mental images.
4. Self corresponds in neuro science to self model defining a model for organism and for the external world. Information or negentropy seems to be necessary for understanding self. Negentropically entangled states - Akashic records - are excellent candidates for selves and would thus correspond to dark matter in TGD sense since the number of states in superposition corresponds to the integer n defining h_{eff} . It is enough that self is potentially conscious: this could mean that its conscious experience about self is generated only in interaction free measurement. Repeated state function reductions to given boundary of CD is second possibility. This would assign irreversibility and definite arrow of time and experience of time flow with self.
5. CDs would serve as embedding space correlates of selves and quantum jumps would be followed by cascades of state function reductions beginning from given CD and proceeding downwards to the smaller scales (smaller CDs). At space-time level space-time sheets in given p-adic length scale would be the natural correlates of selves. One ends also ends up with concrete ideas about how the localization of the contents of sensory experience and cognition to the “upper” (changing) boundary of CD could take place. One cannot exclude the possibility that state function reduction cascades could also take place in parallel branches of the quantum state.

1.2.4 Relationship To Quantum Measurement Theory

TGD based quantum measurement has several new elements. Negentropic entanglement and hierarchy of Planck constants, NMP, the prediction that state function reduction can take place to both boundaries of CD implying that the arrow of geometric time can change (this is expected to occur in microscopic scales whether the arrow of time is not established), and the possibility to understand the flow and arrow of geometric time.

1. The standard quantum measurement theory a la von Neumann involves the interaction of brain with the measurement apparatus. If this interaction corresponds to entanglement between microscopic degrees of freedom m with the macroscopic effectively classical degrees of freedom M characterizing the reading of the measurement apparatus coded to brain state, then the reduction of this entanglement in quantum jump reproduces standard quantum measurement theory provide the unitary time evolution operator U acts as flow in zero mode degrees of freedom and correlates completely some orthonormal basis of WCW spinor fields in non-zero modes with the values of the zero modes. The flow property guarantees that the localization is consistent with unitarity: it also means 1-1 mapping of quantum state basis to classical variables (say, spin direction of the electron to its orbit in the external magnetic field).
2. The assumption that localization occurs in zero modes in each quantum jump implies that the world of conscious experience looks classical. It is also consistent with the state function reduction of the standard quantum measurement theory as the following arguments demonstrate (it took incredibly long time to realize this almost obvious fact!).
3. Since zero modes represent classical information about the geometry of space-time surface (shape, size, classical Kähler field, ...), they have interpretation as effectively classical degrees of freedom and are the TGD counterpart of the degrees of freedom M representing the reading of the measurement apparatus. The entanglement between quantum fluctuating non-zero modes and zero modes is the TGD counterpart for the $m - M$ entanglement. Therefore the localization in zero modes is equivalent with a quantum jump leading to a final state where the measurement apparatus gives a definite reading.

This simple prediction is of utmost theoretical importance since the black box of the quantum measurement theory is reduced to a fundamental quantum theory. This reduction is implied by the replacement of the notion of a point like particle with particle as a 3-surface. Also the infinite-dimensionality of the zero mode sector of the WCW of 3-surfaces is absolutely essential. Therefore the reduction is a triumph for quantum TGD and favors TGD against string models.

Standard quantum measurement theory involves also the notion of state preparation which reduces to the notion of self measurement. In ZEO state preparation corresponds at some level of the self hierarchy to the a state function reduction to boundary opposite than before. In biology sensory perception and motor action would correspond to state function reduction sequences at opposite boundaries of CDs at some levels of the hierarchy.

Self measurement is governed by Negentropy Maximization Principle (NMP) stating that the information content of conscious experience is maximized. In the self measurement the density matrix of some subsystem of a given self localized in zero modes (after ordinary quantum measurement) is measured. The self measurement takes place for that subsystem of self for which the reduction of the entanglement entropy is maximal in the measurement. In p-adic context NMP can be regarded as the variational principle defining the dynamics of cognition. In real context self measurement could be seen as a repair mechanism allowing the system to fight against quantum thermalization by reducing the entanglement for the subsystem for which it is largest (fill the largest hole first in a leaking boat).

1.2.5 Selves Self-Organize

The fourth basic element is quantum theory of self-organization based on the identification of quantum jump as the basic step of self-organization [K101]. Quantum entanglement gives rise to the generation of long range order and the emergence of longer p-adic length scales corresponds to the emergence of larger and larger coherent dynamical units and generation of a slaving hierarchy. Energy (and quantum entanglement) feed implying entropy feed is a necessary prerequisite for quantum self-organization. Zero modes represent fundamental order parameters and localization in zero modes implies that the sequence of quantum jumps can be regarded as hopping in the zero modes so that Haken's classical theory of self organization applies almost as such. Spin glass analogy is a further important element: self-organization of self leads to some characteristic pattern selected by dissipation as some valley of the "energy" landscape.

Dissipation can be regarded as the ultimate Darwinian selector of both memes and genes. The mathematically ugly irreversible dissipative dynamics obtained by adding phenomenological dissipation terms to the reversible fundamental dynamical equations derivable from an action principle can be understood as a phenomenological description replacing in a well defined sense the series of reversible quantum histories with its envelope.

ZEO brings in important additional element to the theory of self-organization. The maxima of Kähler function corresponds to the most probable 3-surfaces. Kähler function receives contributions only from the Euclidian regions ("lines" of generalized Feynman diagrams) whereas the contribution to vacuum functional from Minkowskian regions is exponent of imaginary action so that saddle points with stationary phase are in question in these regions. In ZEO 3-surfaces are replaced by pairs of 3-surfaces at opposite boundaries of CD. The maxima actually correspond to temporal patterns of classical fields connecting these 3-surfaces: this means that self-organization is four spatiotemporal rather than spatial patterns - a crucial distinction from the usual view allowing to understand the evolution of behavioral patterns quantally. In biology this allows to understand temporal evolutions of organisms as the most probable self-organization patterns having as correlates the evolutions of the magnetic body of the system.

1.2.6 Classical Non-Determinism Of Kähler Action

A further basic element is non-determinism of Kähler action. This led to the concepts of association sequence and cognitive space-time sheet, which are not wrong notions but replaced by new ones.

1. The huge vacuum degeneracy of the Kähler action suggests strongly that the preferred is not always unique. For instance, a sequence of bifurcations can occur so that a given space-time branch can be fixed only by selecting a finite number of 3-surfaces with time like(!) separations on the orbit of 3-surface. Quantum classical correspondence suggest an alternative formulation. Space-time surface decomposes into maximal deterministic regions and their temporal sequences have interpretation a space-time correlate for a sequence of quantum states defined by the initial (or final) states of quantum jumps. This is consistent with the fact that the variational principle selects preferred extremals of Kähler action as generalized Bohr orbits.
2. In the case that non-determinism is located to a finite time interval and is microscopic, this sequence of 3-surfaces has interpretation as a simulation of a classical history, a geometric correlate for contents of consciousness. When non-determinism has long lasting and macroscopic effect one can identify it as volitional non-determinism associated with our choices. Association sequences relate closely with the cognitive space-time sheets defined as space-time sheets having finite time duration.

Later a more detailed view about non-determinism in the framework of ZEO has emerged and quantum criticality is here the basic notion. The space-time surface connecting two 3-surfaces at the ends of CD is not unique. Conformal transformations which act trivially at the ends of space-time surface generate a continuum of new extremals with the same value of Kähler action and classical conserved quantities. The number n of conformal equivalence classes is finite and defines the value of h_{eff} (see **Fig.** <http://tgdtheory.fi/appfigures/planckhierarchy.jpg> or **Fig. ??** in the appendix of this book). There exists a hierarchy of breakdowns of conformal symmetry labelled by n . The fractal hierarchy of CDs gives rise to fractal hierarchy of non-determinisms of this kind.

1.2.7 P-Adic Physics As Physics Of Cognition

A further basic element adds a physical theory of cognition to this vision. TGD space-time decomposes into regions obeying real and p-adic topologies labelled by primes $p = 2, 3, 5, \dots$. p-Adic regions obey the same field equations as the real regions but are characterized by p-adic non-determinism since the functions having vanishing p-adic derivative are pseudo constants which are piecewise constant functions. Pseudo constants depend on a finite number of positive binary digits of arguments just like numerical predictions of any theory always involve decimal cutoff. This means that p-adic space-time regions are obtained by gluing together regions for which integration

constants are genuine constants. The natural interpretation of the p-adic regions is as cognitive representations of real physics. The freedom of imagination is due to the p-adic non-determinism. p-Adic regions perform mimicry and make possible for the Universe to form cognitive representations about itself. p-Adic physics space-time sheets serve also as correlates for intentional action.

A more precise formulation of this vision requires a generalization of the number concept obtained by fusing reals and p-adic number fields along common rationals (in the case of algebraic extensions among common algebraic numbers). This picture is discussed in [K120]. The application of this notion at the level of the embedding space implies that embedding space has a book like structure with various variants of the embedding space glued together along common rationals (algebraics, see **Fig. <http://tgdtheory.fi/appfigures/book.jpg>** or **Fig. ??** in the appendix of this book). The implication is that genuinely p-adic numbers (non-rationals) are strictly infinite as real numbers so that most points of p-adic space-time sheets are at real infinity, outside the cosmos, and that the projection to the real embedding space is discrete set of rationals (algebraics). Hence cognition and intentionality are almost completely outside the real cosmos and touch it at a discrete set of points only.

This view implies also that purely local p-adic physics codes for the p-adic fractality characterizing long range real physics and provides an explanation for p-adic length scale hypothesis stating that the primes $p \simeq 2^k$, k integer are especially interesting. It also explains the long range correlations and short term chaos characterizing intentional behavior and explains why the physical realizations of cognition are always discrete (say in the case of numerical computations). Furthermore, a concrete quantum model for how intentions are transformed to actions emerges.

The discrete real projections of p-adic space-time sheets serve also space-time correlate for a logical thought. It is very natural to assign to p-adic binary digits a p -valued logic but as such this kind of logic does not have any reasonable identification. p-Adic length scale hypothesis suggests that the $p = 2^k - n$ binary digits represent a Boolean logic B^k with k elementary statements (the points of the k -element set in the set theoretic realization) with n taboos which are constrained to be identically true.

1.2.8 P-Adic And Dark Matter Hierarchies And Hierarchy Of Selves

Dark matter hierarchy assigned to a spectrum of Planck constant having arbitrarily large values brings additional elements to the TGD inspired theory of consciousness.

1. Macroscopic quantum coherence can be understood since a particle with a given mass can in principle appear as arbitrarily large scaled up copies (Compton length scales as \hbar). The phase transition to this kind of phase implies that space-time sheets of particles overlap and this makes possible macroscopic quantum coherence.
2. The space-time sheets with large Planck constant can be in thermal equilibrium with ordinary ones without the loss of quantum coherence. For instance, the cyclotron energy scale associated with EEG turns out to be above thermal energy at room temperature for the level of dark matter hierarchy corresponding to magnetic flux quanta of the Earth's magnetic field with the size scale of Earth and a successful quantitative model for EEG results [K44].

Dark matter hierarchy leads to detailed quantitative view about quantum biology with several testable predictions [K44]. The general prediction is that Universe is a kind of inverted Mandelbrot fractal for which each bird's eye of view reveals new structures in long length and time scales representing scaled down copies of standard physics and their dark variants. These structures would correspond to higher levels in self hierarchy. This prediction is consistent with the belief that 75 per cent of matter in the universe is dark.

1. *Living matter and dark matter*

Living matter as ordinary matter quantum controlled by the dark matter hierarchy has turned out to be a particularly successful idea. The hypothesis has led to models for EEG predicting correctly the band structure and even individual resonance bands and also generalizing the notion of EEG [K44]. Also a generalization of the notion of genetic code emerges resolving the paradoxes related to the standard dogma [K68, K44]. A particularly fascinating implication is the possibility

to identify great leaps in evolution as phase transitions in which new higher level of dark matter emerges [K44].

It seems safe to conclude that the dark matter hierarchy with levels labelled by the values of Planck constants explains the macroscopic and macro-temporal quantum coherence naturally. That this explanation is consistent with the explanation based on spin glass degeneracy is suggested by following observations. First, the argument supporting spin glass degeneracy as an explanation of the macro-temporal quantum coherence does not involve the value of \hbar at all. Secondly, the failure of the perturbation theory assumed to lead to the increase of Planck constant and formation of macroscopic quantum phases could be precisely due to the emergence of a large number of new degrees of freedom due to spin glass degeneracy. Thirdly, the phase transition increasing Planck constant has concrete topological interpretation in terms of many-sheeted space-time consistent with the spin glass degeneracy.

2. Dark matter hierarchy and the notion of self

The vision about dark matter hierarchy leads to a more refined view about self hierarchy and hierarchy of moments of consciousness [K43, K44]. The larger the value of Planck constant, the longer the life-time of self measured as the increase of the average distance between tips of CDs appearing in the quantum superposition during the period of repeated reductions not affecting the part of the zero energy state at the other boundary of CD- Quantum jumps form also a hierarchy with respect to p-adic and dark hierarchies and the geometric durations of quantum jumps scale like \hbar .

The fact that we can remember phone numbers with 5 to 9 digits supports the view that self experience subelves as separate mental images. Averaging over experiences of sub-selves of sub-self would however occur.

3. The time span of long term memories as signature for the level of dark matter hierarchy

The basic question is what time scale can one assign to the geometric duration of quantum jump measured naturally as the size scale of the space-time region about which quantum jump gives conscious information. This scale is naturally the size scale in which the non-determinism of quantum jump is localized. During years I have made several guesses about this time scales but zero energy ontology and the vision about fractal hierarchy of quantum jumps within quantum jumps leads to a unique identification.

CD as an embedding space correlate of self defines the time scale τ for the space-time region about which the consciousness experience is about. The temporal distances between the tips of CD as come as integer multiples of CP_2 length scales and for prime multiples correspond to what I have christened as secondary p-adic time scales. A reasonable guess is that secondary p-adic time scales are selected during evolution and the primes near powers of two are especially favored. For electron, which corresponds to Mersenne prime $M_{127} = 2^{127} - 1$ this scale corresponds to 0.1 seconds defining the fundamental time scale of living matter via 10 Hz biorhythm (alpha rhythm). The unexpected prediction is that all elementary particles correspond to time scales possibly relevant to living matter.

Dark matter hierarchy brings additional finesse. For the higher levels of dark matter hierarchy τ is scaled up by \hbar/\hbar_0 . One could understand evolutionary leaps as the emergence of higher levels at the level of individual organism making possible intentionality and memory in the time scale defined τ .

Higher levels of dark matter hierarchy provide a neat quantitative view about self hierarchy and its evolution. Various levels of dark matter hierarchy would naturally correspond to higher levels in the hierarchy of consciousness and the typical duration of life cycle would give an idea about the level in question. The level would determine also the time span of long term memories as discussed in [K44]. The emergence of these levels must have meant evolutionary leap since long term memory is also accompanied by ability to anticipate future in the same time scale. This picture would suggest that the basic difference between us and our cousins is not at the level of genome as it is usually understood but at the level of the hierarchy of magnetic bodies [K68, K44]. In fact, higher levels of dark matter hierarchy motivate the introduction of the notions of super-genome and hyper-genome. The genomes of entire organ can join to form super-genome expressing genes coherently. Hyper-genomes would result from the fusion of genomes of different organisms and collective levels of consciousness would express themselves via hyper-genome and make possible

social rules and moral.

1.3 Quantum Biology And Quantum Neuroscience In TGD Universe

Quantum biology - rather than only quantum brain - is an essential element of Quantum Mind in TGD Universe. Cells, biomolecules, and even elementary particles are conscious entities and the biological evolution is evolution of consciousness so that it would be very artificial to restrict the discussion to brain, neurons, or microtubules.

1.3.1 Basic Physical Ideas

The following list gives the basic elements of TGD inspired quantum biology.

1. Many-sheeted space-time allows the interpretation of the structures of macroscopic world around us in terms of space-time topology. Magnetic/body acts as intentional agent using biological body as a sensory receptor and motor instrument and controlling biological body and inheriting its hierarchical fractal structure. Fractal hierarchy of EEGs and its variants can be seen as communication and control tools of magnetic body. Also collective levels of consciousness have a natural interpretation in terms of magnetic body. Magnetic body makes also possible entanglement in macroscopic length scales. The braiding of magnetic flux tubes makes possible topological quantum computations and provides a universal mechanism of memory. One can also understand the real function of various information molecules and corresponding receptors by interpreting the receptors as addresses in quantum computer memory and information molecules as ends of flux tubes which attach to these receptors to form a connection in quantum web.
2. Magnetic body carrying dark matter and forming an onion-like structure with layers characterized by large values of Planck constant is the key concept of TGD inspired view about Quantum Mind to biology. Magnetic body is identified as intentional agent using biological body as sensory receptor and motor instrument. EEG and its fractal variants are identified as a communication and control tool of the magnetic body and a fractal hierarchy of analogs of EEG is predicted. Living system is identified as a kind of Indra's net with biomolecules representing the nodes of the net and magnetic flux tubes connections between them.

The reconnection of magnetic flux tubes and phase transitions changing Planck constant and therefore the lengths of the magnetic flux tubes are identified as basic mechanisms behind DNA replication and analogous processes and also behind the phase transitions associated with the gel phase in cell interior. The braiding of magnetic flux makes possible universal memory representation recording the motions of the basic units connected by flux tubes. Braiding also defines topological quantum computer programs updated continually by the flows of the basic units. The model of DNA as topological quantum computer is discussed as an application. In zero energy ontology the braiding actually generalize to 2-braiding for string world sheets in 4-D space-time and brings in new elements.

3. Zero energy ontology (ZEO) makes possible the proposed p-adic description of intentions and cognitions and their transformations to action. Time mirror mechanism (see **Fig.** <http://tgdtheory.fi/appfigures/timemirror.jpg> or **Fig. ??** in the appendix of the book) based on sending of negative energy signal to geometric past would apply to both long term memory recall, remote metabolism, and realization of intentional acting as an activity beginning in the geometric past in accordance with the findings of Libet. ZEO gives a precise content to the notion of negative energy signal in terms of zero energy state for which the arrow of geometric time is opposite to the standard one.

The associated notion of causal diamond (CD) is essential element and assigns to elementary particles new fundamental time scales which are macroscopic: for electron the time scale is 1 seconds, the fundamental biorhythm. An essentially new element is time-like entanglement which allows to understand among other things the quantum counterparts of Boolean functions in terms of time-like entanglement in fermionic degrees of freedom.

4. The assignment of dark matter with a hierarchy of Planck constants gives rise to a hierarchy of macroscopic quantum phases making possible macroscopic and macrotemporal quantum coherence and allowing to understand evolution as a gradual increase of Planck constant. The model for dark nucleons leads to a surprising conclusion: the states of nucleons correspond to DNA, RNA, tRNA, and amino-acids in a natural manner and vertebrate genetic code as correspondence between DNA and amino-acids emerges naturally. This suggests that genetic code is realized at the level of dark hadron physics and living matter in the usual sense provides a secondary representation for it.

The hierarchy of Planck constants emerges from basic TGD under rather general assumptions. The key element is the huge vacuum degeneracy which implies that preferred non-vacuum extremals of Kähler action form a 4-D spin glass phase. The basic implications following from the extreme non-linearity of Kähler action is that normal derivatives of embedding space coordinates at 3-D light-like orbits of partonic 2-surfaces and at space-like 3-surfaces at ends of CDs are many-valued functions of canonical momentum densities: this is one of the reasons that forced to develop physics as an infinite-D Kähler geometry vision instead of trying to develop path integral formalism or canonical quantization. A convenient manner to treat the situation is to introduce local many-sheeted covering of embedding space such that the sheets are completely degenerate at partonic 2-surfaces. This leads in natural manner to the hierarchy of Planck constants as effective hierarchy hierarchy and integer multiples of Planck constants emerge naturally.

5. p-Adic physics can be identified as physics of cognition and intentionality. The hierarchy of p-adic length scales predicts a hierarchy of universal metabolic quanta as increments of zero point kinetic energies. Negentropic entanglement (see **Fig.** <http://tgdtheory.fi/appfigures/cat.jpg> or **Fig. ??** in the appendix of this book) possible for number theoretic entanglement entropy makes sense for rational (and even algebraic) entanglement and leads to the identification of life as something residing in the intersection of real and p-adic worlds. NMP respects negentropic entanglement and the attractive idea is that the experience of understanding and positively colored emotions relate to negentropic entanglement.
6. Living matter as conscious hologram is one of the basic ideas of TGD inspired biology and consciousness theory. The basic objection against TGD is that the interference of classical fields is impossible in the standard sense for the reason that classical fields are not primary dynamical variables in TGD Universe. The resolution is based on the observation that only the interference of the effects caused by these fields can be observed experimentally and that many-sheeted space-time allows to realized the summation of effects in terms of multiple topological condensations of particles to several parallel space-time sheets. One concrete implication is fractality of qualia. Qualia appear in very wide range of scales: our qualia could in fact be those of magnetic body. The proposed mechanism for the generation of qualia realizes the fractality idea.

1.3.2 Brain In TGD Universe

Brain cognizes and one should find physical correlates for cognition. Also the precise role of brain in information processing and its relationship to metabolism should be understood. Here magnetic body brings as a third player to the couple formed by environment and organism.

1. An attractive idea is that the negentropic entanglement can be assigned with magnetic flux tubes somehow and that ATP serves as a correlate for negentropic entanglement. This leads to a rather detailed ideas about the role of phosphate bond and provides interpretation for the fact that the number of valence bonds tend to be maximized in living matter. In a loose sense one could even call ATP a consciousness molecule. The latest view encourages to consider the possibility that negentropic entanglement with what might be called Mother Gaia is what is transferred in metabolism.
2. The view about the function of brain differs from the standard view. The simplest option is that brain is a builder of symbolic representations building percepts and giving them names rather than the seat of primary qualia relevant to our conscious experience. Sensory organs

would carry our primary qualia and brain would build sensory percepts as standardized mental images by using virtual sensory input to the sensory organs. The new view about time is absolutely essential for circumventing the objections against this vision. The prediction is that also neuronal and even cell membranes define sensory maps with primary qualia assignable to the lipids serving as pixels of the sensory screen. These qualia would not however represent our qualia but lower level qualia. At this moment it is not possible to choose between these two options.

3. The role of EEG and its various counterparts at fractally scaled frequency ranges is to make possible communications to the various onion-like layers of the magnetic body and the control by magnetic body. Dark matter at these layers could be seen as the intentional agent and sensory perceiver.

1.3.3 Anomalies

Various anomalies of living matter have been in vital role in the development of not only TGD view about living matter but also TGD itself.

1. TGD approach to living matter was strongly motivated by the findings about strange behavior of cell membrane and of cellular water, and gel behavior of cytoplasm. Also the findings about effects of ELF em fields on vertebrate brain were decisive and led to the proposal of the hierarchy of Planck constants found later to emerge naturally from the non-determinism of Kähler action. Rather satisfactorily, the other manner to introduce the hierarchy of Planck constants is in terms of gravitational Planck constant: at least in microscopic scales the equivalence of these approaches makes sense and leads to highly non-trivial predictions. The basic testable prediction is that dark photons have cyclotron frequencies inversely proportional to their masses but universal energy spectrum in visible and UV range which corresponds to the transition energies for biomolecules so that they are ideal for biocontrol at the level of both magnetic bodies and at the level of biochemistry.
2. Water is in key role in living matter and also in TGD inspired view about living matter. The anomalies of water lead to a model for dark nuclei as dark proton strings with the surprising prediction that DNA, RNA, amino-acids and even tRNA are in one-one correspondence with the resulting 3-quark states and that vertebrate genetic code emerges naturally. This leads to a vision about water as primordial life form still playing a vital role in living organisms. The model of water memory and homeopathy in turn generalizes to a vision about how immune system might have evolved.
3. Metabolic energy is necessary for conscious information processing in living matter. This suggests that metabolism should be basically transfer of negentropic entanglement from nutrients to the organism. ATP could be seen as a molecule of consciousness in this picture and high energy phosphate bond would make possible the transfer of negentropy.

1.3.4 Organization of Bio-Systems as Conscious Holograms

Brain as a hologram is an old idea and it emerges naturally also in TGD framework both at quantum and classical level, which by quantum classical correspondence is expected to reflect what happens at the deeper quantum level.

The book was written long time ago and necessarily contains mammoth bones - my sincere apologies. The book is organized into 2 parts.

1. The 1st part of the book contains four chapters about this topic reflecting the development of ideas about TGD Universe as conscious hologram. It also provides background for the applications.

The first chapter is about macroscopic quantum coherence and 4-D spin-glass degeneracy. This notion emerged from the huge vacuum degeneracy of Kähler and involves also non-determinism. The twistor lift of TGD introduces to the action volume term having interpretation in terms of length scale dependent cosmological constant but the dynamical

cosmological constant can also vanish. Second chapter is about what the phrase bio-systems as conscious holograms could mean.

The third chapter about general theory of qualia. In particular, a general model of sensory qualia and a model for sensory receptor as electret, which are very abundant in living matter, are discussed.

Fourth chapter is about the notion of time and is inspired by zero energy ontology. It provides a vision about how the arrow of geometric time correlating with the arrow of experienced time and the localization of the contents of sensory experience to a narrow time interval emerge.

2. The 2nd part of the book is devoted to water memory and metabolism. Obviously, a connection between these two suggests itself. A discovery - certainly one of the greatest surprises of my professional life - popped up as an outcome of an attempt to understand the mechanism behind water memory for which rather strong support exists now. The idea was that dark nuclei which sizes zoomed up to atomic size scale could provide a representation of genes with dark nucleons consisting of three quarks representing DNA codons. It turned out that the model for dark nucleon consisting of three quarks predicts counterparts of 64 DNAs, 64 RNAs, and 20 amino-acids and allows to identify vertebrate genetic code as a natural mapping of DNA type states to amino-acid type states. The population of dark nuclei would be new life-form possibly responsible for the water memory.

The first chapter is about water memory and somewhat provocatively titled Homeopathy in many-sheeted space-time. Second chapter added rather recently is about cancer as disease of magnetic body. There are two chapters about metabolism and macroscopic quantum coherence and the last chapter is about remote metabolism providing in zero energy ontology a new mechanism of metabolism.

The chapter about metabolism represents a possible model of metabolism based on the identification of universal metabolic energy quanta as increments of zero point kinetic energies emitted or absorbed as particles are transferred between space-time time sheets characterized by different p-adic primes. This model is only one of the many alternatives: what is required is a system analogous to a laser with population reversal receiving negative energy signals and dropping to a lower energy state. Remote metabolism is achieved by sending negative energy signals to this kind of system.

During last 15 years a real understanding of metabolism in terms of zero energy ontology (ZEO) based theory of consciousness and hierarchy of Planck constants $h_{eff} = n \times h_0$ has emerged. The chapters of this book were written for the first time about two decades and fail to fully reflect this progress.

1.4 Sources

The eight online books about TGD [K137, K130, K100, K81, K25, K78, K59, K114] and nine online books about TGD inspired theory of consciousness and quantum biology [K127, K22, K90, K20, K55, K66, K70, K113, K125] are warmly recommended for the reader willing to get overall view about what is involved.

My homepage (<http://tinyurl.com/ybv8dt4n>) contains a lot of material about TGD. In particular, a TGD glossary at <http://tinyurl.com/yd6jf3o7>).

I have published articles about TGD and its applications to consciousness and living matter in *Journal of Non-Locality* (<http://tinyurl.com/ycyrxj4o> founded by Lian Sidorov and in *Prespacetime Journal* (<http://tinyurl.com/ycvktjhn>), *Journal of Consciousness Research and Exploration* (<http://tinyurl.com/yba4f672>), and *DNA Decipher Journal* (<http://tinyurl.com/y9z52khg>), all of them founded by Huping Hu. One can find the list about the articles published at <http://tinyurl.com/ybv8dt4n>. I am grateful for these far-sighted people for providing a communication channel, whose importance one cannot overestimate.

1.5 The contents of the book

1.5.1 PART I: BIO-SYSTEMS AS CONSCIOUS HOLOGRAMS

Macro-Temporal Quantum Coherence and Spin Glass Degeneracy

The basic objection against quantum consciousness theories is that the de-coherence times for macroscopic quantum states are quite too short. This argument has been put in quantitative form by Mark Tegmark.

These counter arguments are however problematic. First of all, the notions of quantum coherence and de-coherence are problematic in standard physics framework since the non-determinism of the state function reduction is in conflict with the determinism of Schrödinger equation. The intuitive idea is however that one can estimate the de-coherence times as essentially lifetimes of quantum states. Secondly, the estimates for de-coherence times are based on standard physics, and it is quite possible that new physics is essential for understanding living matter. The belief that standard physics is enough is based only on the reductionistic dogma.

Penrose and Hameroff have proposed that some future theory of quantum gravitation makes it possible to replace the phenomenological notion of state function reduction with a more fundamental notion which they call Orch OR, that quantum gravitational effects make possible macroscopic quantum states of required long de-coherence time, and that micro-tubules are the systems, where these effects are especially important so that one might even speak about reduction of the consciousness to the micro-tubular level. Penrose and Hameroff have also proposed that micro-tubules could act as quantum computers. The quantum states involved would be quantum superpositions of tubulin conformations and quantum gravitation would somehow make these quantum superpositions stable. Long enduring quantum superpositions of the conformations of (say tubulin) molecules would allow to perform a multi-verse simulation for the conformational behaviour of the molecules and this would certainly have evolutionary value.

1. Macrotemporal quantum coherence is suggested by quantum classical correspondence

TGD inspired theory of consciousness leads to a first principle theory of state function reduction and preparation free of the logical paradoxes, allows precise definitions for the notions of quantum coherence and de-coherence, and predicts a mechanism making the lifetimes of macroscopic bound states much longer than predicted by the standard physics. By quantum-classical correspondence the argument can be formulated at space-time level and configuration space (world of classical worlds (WCW)) level. An especially relevant notion is negentropic entanglement which from the consistency with ordinary quantum measurement theory is described by density matrix proportional to unit matrix. In quantum computation entanglement matrix proportional to a unitary matrix gives rise to negentropic entanglement and by NMP this entanglement is stable against state function reduction by Negentropy Maximization Principle (NMP).

At embedding space level causal diamonds (CDs) define the correlates for coherence regions. At the space-time level coherence regions are identifiable as space-time sheets. They indeed are coherence regions for both classical fields and induced spinor fields defining single particle limit of the quantum theory. By quantum criticality of TGD Universe there is no upper bound for neither the spatial or temporal size of the space-time sheet and one obtains a p-adic hierarchy of coherence lengths and de-coherence times. Finiteness of de-coherence time corresponds to the fact that energy flows to the space-time sheet from larger space-time sheet first and then back. Note that in the standard quantum field theory the entire Minkowski space M^4 is the natural identification for the coherence region, and it is difficult to understand how to describe the reduction to a smaller region of M^4 .

2. Macrotemporal quantum coherence from spin glass degeneracy?

At WCW level the argument supporting macroscopic and macrotemporal quantum coherence goes as follows. The basic distinction between TGD and standard physics is quantum spin glass degeneracy, which among other things implies that quantum bound states of, say, two molecules have enormous spin glass degeneracy absent in the free state. The intuitive expectation is that the system spends much longer time in bound states than in free states and this implies much longer de-coherence time than expected otherwise.

One can formulate this argument more rigorously using unitarity conditions implying that forward scattering amplitude for bound states is very large due to the spin glass degeneracy. The almost degenerate spin glass states differ only by their classical gravitational energy so that gravitation is indeed important. The importance of quantum gravitation is also obvious from the fact that genuine quantum gravitational states are state functionals in the world of worlds rather than in world so that they are expected to represent in some sense higher abstraction level than ordinary quantum states in the hierarchy of consciousness.

3. *Hierarchy of Planck constants and dark matter hierarchy*

The non-determinism of Kähler action and ensuing quantum criticality strongly suggests a dark matter hierarchy with levels labelled by values of (effective) Planck constant $\hbar_{eff} = n \times \hbar$. The implications are non-trivial already at the level of hadron physics and nuclear physics and imply that condensed matter physics and nuclear physics are not completely disjoint disciplines as reductionism teaches us. One condensed matter application is a model of high T_c superconductivity predicting that the basic length scales of cell membrane and cell as scales are inherent to high T_c superconductors.

Living matter as ordinary matter quantum controlled by the dark matter hierarchy has turned out to be a particularly successful idea. The hypothesis has led to models for EEG predicting correctly the band structure and even individual resonance bands and also generalizing the notion of EEG. Also a generalization of the notion of genetic code emerges resolving the paradoxes related to the standard dogma. A particularly fascinating implication is the possibility to identify great leaps in evolution as phase transitions in which new higher level of dark matter emerge.

It seems safe to conclude that the dark matter hierarchy with levels labelled by the values of Planck constants explains the macroscopic and macro-temporal quantum coherence naturally. That this explanation is consistent with the explanation based on spin glass degeneracy is suggested by the fact that both follow from the non-determinism of Kähler action and relate closely to quantum criticality.

Bio-Systems as Conscious Holograms

The notion of conscious hologram is TGD based generalization of the idea about brain as a hologram. In nutshell, the notion of conscious hologram follows from the topological field quantization. Classical fields and matter form a Feynmann diagram like structure consisting of lines representing matter (say charged particles) and bosons (say photons). The matter lines are replaced by space-time sheets representing matter (elementary particles, atoms, molecules,...), and virtual bosons are replaced by topological light rays (“massless extremals”, MEs). Also magnetic flux tubes appear and together with MEs they serve as correlates for bound state quantum entanglement.

The internal lines of generalized Feynmann diagram are analogous to wave guides and the classical fields and coherent light propagating along these wave guides interfere at the space-time sheets representing the vertices of the generalized Feynmann diagram and the “points” of the conscious hologram. The formation of the hologram corresponds to the self-organization induced by the leakage of supra currents to smaller (say atomic) space-time sheets. This leakage is induced by the high frequency MEs propagating along low frequency MEs serving as correlates for quantum entanglement. The 3-D stereovision associated with ordinary hologram is generalized to stereo consciousness resulting, when the mental images associated with different “points” of conscious hologram fuse to single mental image. Central nervous system can be regarded as a conscious hologram of this kind.

Time mirror mechanism is a key element of intentional action. The notion of four-wave interaction generalizes: the interference pattern of oppositely moving reference waves forming an archetypal standing wave (possibly moving as in case of nerve pulse) can be replaced by any synchronously oscillating periodic spatial pattern. Plasma waves for which the frequency does not depend on wave vector are ideal candidates for holograms in the generalized sense. Living matter would be full of this kind of holograms: besides plasma oscillations associated with biologically important ions, also Z^0 plasma oscillations associated with atoms and molecules can define holograms. p-Adic length scale hypothesis predicts a hierarchy of plasma frequencies related by powers $2^{3k/4}$ so that even so called “non-living matter” could build this kind of sensory representations based on plasma oscillations.

ZEO predicts that vacuum functional is maximum for preferred pairs of 3-surfaces located at opposite boundaries of causal diamond (CD). Hence self-organization by quantum jump sequences leads to preferred geometro-temporal patterns rather than asymptotic 3-D patterns. In biology these temporal patterns dominate and it is very difficult to understand this in standard ontology: morphogenesis is basic example of this.

p-Adic length scale hypothesis and dark matter hierarchy allow to quantify the notion of conscious hologram. The hierarchy of generalized EEGs associated with the dark matter hierarchy allows to propose concrete mechanism of remote mental interactions playing a key role also in the interaction of magnetic bodies with the biological body. Experimental findings related to anomalous pre-cognition support the view that even galactic magnetosphere acts as a conscious entity receiving sensory input from bio-sphere and controlling it.

Bio-photons provide an application of the general theory. Simple mathematical facts about the delayed luminescence induced by an external perturbation combined with the model for a hierarchy of dark EEGs assignable to that of Josephson junctions, lead to a model in which positive and negative energy MEs transversal to DNA strand and representing dark photons generate coherent bio-photons via de-coherence. Rather detailed quantitative models for how MEs and supra current circuits interact and how bio-photons are generated during the gene expression emerge.

Peter Gariaev and his group have discovered a radio wave emission from DNA induced by laser light. The model explaining delayed luminescence covers also this phenomenon: now the decay of dark photons with energies above thermal threshold to radio-wave photons rather than de-coherence would be the mechanism. The findings allow an explanation in terms of a many-sheeted laser action, and a rather detailed view about how bio-system acts as a many-sheeted laser at a wide wave-length range emerges.

William Tiller in Stanford University has carried out impressive experimental work with what he calls intention imprinted electronic devices (IIED), and his results challenge that standard assumption that the intentions of experimenter do not affect the experimental apparatus. The analysis of the work of Tiller in the conceptual framework of TGD leads to the conclusion that four-wave interaction, which is a basic mechanism to produce phase conjugate waves (negative energy topological light rays), serves also as a basic mechanism of intentional action. This leads to a unified view allowing to see EEG and nerve pulse as a particular realization of four-wave interaction.

General Theory of Qualia

The connection between the general theory of qualia and quantum measurement theory and thermodynamics turned out to be a breakthrough in the development of the ideas related to qualia.

1. *The notion of self and qualia*

The notion of self has been problematic and the recent progress in this respect clarifies also the situation concerning qualia. In ordinary quantum measurement theory repetition of state function reduction leaves the state unchanged. In TGD state function reduction can occur at both boundaries of causal diamond (CD) and in this case the state remains invariant only at the boundary at which the repetition takes place. This allows to understand how the arrow of time and its flow correspond essentially the increase of the average temporal distance between the tips present in the superposition of CDs with second end localized at fixed light-cone boundary. Self can be identified as a sequence of state function reductions occurring at given boundary of CD. The act of free will corresponds to the occurrence of quantum jump to the opposite boundary of CD and changes the arrow of geometric time at the level of the hierarchy of CDs corresponding to self. Qualia must characterize to the experiences of self assignable to the repeated state function reductions.

The original model of qualia was based on the idea that all quantum jumps involve change of quantum numbers so that increments of quantum numbers would characterize qualia. This assumption does not make sense for the quantum jumps at the fixed boundary of CD but at the opposite boundary of CD flow of quantum numbers between two subsystems is possible. Hence the increments of quantum numbers or rather the rates for their change would characterize qualia. The capacitor model for sensory receptor, which emerged before the correct view about self, actually

assumed this.

2. Model of qualia

One ends up with the following model of qualia.

1. Only the increments of zero modes and quantum numbers are experienced consciously. In the original model these increments were associated with quantum jumps: in the updated model their are associated with a flow of quantum numbers between two sub-systems at the non-fixed boundary of CD.
2. There are geometric qualia corresponding to zero modes expressing the result of quantum measurement in each quantum jump. All geometric information about space-time surface should reduce to geometric qualia. For instance, geometric data given by visual, auditory, and tactile senses should reduce to conscious information about zero modes or about increments of zero modes in quantum jump.
3. A further working hypothesis analogous to functionalism is universality: kinesthetic qualia depending on the quantum number increments are universal. Thus the increments of Poincare and color and electro-weak quantum numbers define what might be called universal kinesthetic qualia.

3. Thermodynamics and qualia

Thermodynamical approach to qualia suggested itself.

1. The sequence of the states assignable to the changing boundary of CD can be modelled as a statistical ensemble of Fock states, which suggests that thermodynamics is basically part of theory of consciousness. The ensemble of prepared states gives rise to a large number of statistical qualia. The relationship $dE = TdS - PdV + \mu dN + B \cdot dM \dots$ generalizes to TGD context: note however that in case of ME selves energy is replaced with the Super Virasoro generator L_0 associated with the light cone boundary of ME. Each intensive-extensive variable pair in the differential should correspond to a non-geometric quale, which results only when there is a gradient (flow) of the extensive variable in the direction of the subjective time. Super-canonical thermodynamics should obviously map ordinary thermodynamics to the level of conscious experience.
2. Statistical interpretation also suggests that an averaging over the increments occurs. The possibility of sub-selves makes possible to have sequences of sub-selves (mental images) of finite subjective time duration and this makes possible structured subjective memories (for instance, it becomes possible to remember the digits of a phone number).

The thermodynamical expression for dE suggests a general classification of qualia consistent with the “holy trinity” of existences implied by TGD. Emotions - such as pain and pleasure - can be identified as order-disorder qualia with the sign of the gradient of negentropy associated with negentropic entanglement defining the coloring of emotion. Kinesthetic qualia are associated with generalized forces: senses of force and torque, hearing, and intensity of color sensation would serve as examples. Generalized chemical qualia correspond to flows between two sub-systems for various quantum numbers such as those associated with charged particles, ions, molecules, Cooper pairs, etc. Chemical qualia and color vision would serve as examples. The fermionic generators of super-conformal algebras and states created by them are labeled by binary digits labeling spin like quantum numbers, whose increments could give rise to Boolean consciousness with intrinsic meaning (“This is true”). The flows associated with these binary digits could define Boolean qualia.

4. How qualia are generated?

There are two basic mechanisms generating sensory qualia.

1. Quantum phase transition in which single particle transition occurs coherently for some macroscopic quantum phase produces qualia defined by the increments of quantum numbers in the transition. Quantum phase transition could be induced by the transition frequency:

quantum phase transition leading to the generation of new kind of macroscopic quantum phase is in question. The magnetic quantum phase transitions at super-conducting magnetic flux tubes provide a basic example of this mechanism, and the quantum model of hearing relies on Z^0 magnetic quantum phase transitions.

2. The flow of particles with fixed quantum numbers between “electrodes” of what might be called a quantum capacitor induces qualia defined by the quantum numbers of the particles involved. The “electrodes” carry opposite net quantum numbers. Second electrode corresponds to the sub-self defining the quale mental image. Obviously cell interior and exterior are excellent candidates for the electrodes of the quantum capacitor. Also neuron and post-synaptic neuron. In fact, living matter is full of electrets defining capacitor like structures. The capacitor model applies to various chemical qualia and also to color vision and predicts that also cells should have senses.

The emergence of zero energy ontology, the explanation of dark matter in terms of a hierarchy of Planck constants requiring a generalization of the notion of embedding space, the view about life as something in the intersection of real and p-adic worlds, and the notion of number theoretic entanglement negentropy led to a breakthrough in TGD inspired quantum biology and also to the recent view of qualia and sensory representations including hearing allowing a precise quantitative model at the level of cell membrane. The ensuing general model of how cell membrane acts as a sensory receptor has unexpected implications for the entire TGD inspired view about biology.

1.5.2 PART II: WATER MEMORY AND METABOLISM

Homeopathy in Many-Sheeted Space-time

The claimed mechanisms of homeopathic healing and the method of manufacturing homeopathic potencies are not the only paradoxical aspects of homeopathy. Also the reported frequency imprinting and entrainment, codes based on field patterns, and associative learning of water look mysterious in the framework of standard physics.

1. Frequency imprinting and entrainment, and scaling laws

Frequency imprinting and entrainment at preferred frequencies are believed to be fundamental for homeopathy and acupuncture.

Homeopathy seems to involve two kinds of scaling laws which seem to be closely related. What I call scaling law of homeopathy states that homeopathic frequencies appear in pairs (f_h, f_l) of high and low frequencies such that their ratio is given by $f_h/f_l \simeq 2 \times 10^{11}$. TGD approach explains this ratio predicts a generalization of the law. $v = Lf_l$ scaling law tells in TGD framework how the frequencies associated with generalized EEG code for the velocities of physiological waves and their frequencies $f_h = cf_l/v$. The general model for motor control by magnetic body predicts this scaling law.

The hierarchy of Planck constants explains this scaling law and generalizes it. The two frequencies correspond to f_l associated with dark photon with $h_{eff} = n \times h$ and to f_h associated with ordinary photon giving $f_h/f_l = n$. Bio-photons would result in energy conserving decays of dark photons to ordinary photons.

2. Basic inputs from TGD

The model for DNA baryon leads to the proposal that genetic code as well as DNA-, RNA- and amino-acid sequences should have representation in terms of nuclear strings. The model for dark baryons indeed leads to an identification of these analogs and the basic numbers of genetic code including also the numbers of amino-acids coded by a given number of codons are predicted correctly. Hence it seems that genetic code is universal rather than being an accidental outcome of the biological evolution.

The findings of Pollack about exclusion zones and fourth phase of water provide additional ideas. In TGD framework exclusion zones would correspond to dark $H_{3/2}O$ phase of water with every fourth hydrogen atom or proton taken to the dark flux tubes. This makes the exclusion zone negatively charged. The magnetic body of this kind of region would define fundamental representation of the magnetic body of the invader molecule. Not only cyclotron frequencies, but

possibly also braiding would be represented, even 2- braiding involving reconnections. This leads to the idea that exclusion zones are primitive life forms having magnetic body containing dark matter. Most importantly, are representation of genetic code in terms of dark proton sequences would be realized at the flux tubes of the magnetic body.

3. How immune system might have evolved?

Organism or prebiotic life form living in water must recognize the invader molecule and here reconnection of the flux tubes of magnetic bodies is here the key mechanism: it would provide basic mechanism of attention and recognition. This requires that the strength of magnetic fields at flux tubes are same and organism could vary it by varying the thickness of the flux tube carrying monopole flux. This would also involve cyclotron resonance taking place simultaneously. If dark ELF photons are involved the cyclotron resonances can have energies visible and UV range characterizing bio-photons. This energy range corresponds also to excitation energies of various bio-molecules.

A further element comes from the observation that dark proton sequences could give rise to dark DNA. These sequences would reside at the flux tubes of the magnetic body associated with the exclusion zone. They would define dark variants of proteins and amino-acids. The key idea is that dark variants of amino-acid sequences would have coded not only for the braiding of the magnetic body of the invader but also for the 2-braiding (temporal development of braiding) of the magnetic flux tube patterns defining invader molecule as a dynamical process: dark proteins would mimic physically the braiding of invader molecule's magnetic body.

Dark DNA sequences would have coded this braiding symbolically and their translation to dark amino-acids would transform symbolic representation to a concrete physical one. The emergence of ordinary DNA and amino-acids would have realized the same at biochemical level and amino-acid sequences representing the invader would serve as antigens attaching to the invader molecule. Not only the pattern produced in protein folding but also the temporal pattern of protein folding would be coded by DNA.

4. Model for the homeopathy

The model of homeopathy must explain the effectiveness of homeopathic remedies manufactured by a repeated dilution and succussion. This can be understood if part of chemical involved is transformed to dark matter and is also represented by water clusters or dark super-nuclei formed from protons. This minimal representation involves thermally stable dark cyclotron frequencies. If inherently dark atoms and molecules with essentially same energy spectrum as ordinary ones are possible, also the mimicry of vibrational and rotational spectrum is possible by clusters of dark water molecules.

One must also understand why homeopathic remedies are manufactured from molecules which basically cause the symptoms to be cured. This brings strongly in mind the functioning of immune system: when the organism is exposed to the substance causing the health problem, immune system develops resistance. Maybe something similar happens in homeopathy in the sense that the homeopathic remedy representing the substance induces resistance. A representation carrying information about the biologically important aspects of the substance would be therefore needed.

This suggests that the manufacturing of the homeopathic remedy generates replicating primitive life forms analogous to the exclusion zones. The repeated mechanical agitation could feed to the system metabolic energy and induce the formation of new exclusion zone like regions mimicking the magnetic body original invader molecule or the already existing representations of it. Even quantal evolution at the level of dark DNA could take place. The final outcome would be population of primitive life forms representing the invader. This representation would in turn induce generation of immune response.

Could Cancer be a Disease of Magnetic Body?

Li and Heroux have made a highly interesting discovery. The treatment of cancer cell population by 60 Hz oscillating magnetic field with extremely small strength above 25 nT leads to a reduction of the abnormally large chromosome number of the mitochondria of cancer cells and eventually the cancer cells return to the normal state.

TGD based explanation for the findings relies on the basic notions of TGD inspired quantum biology. The basic notions are magnetic body (MB) and hierarchy of Planck constants $h_{eff} = n \times h_0$ ($h = 6h_0$) emerging from the adelic physics as a prediction but originally proposed on basis of anomalous effects of ELF em fields in living matter. The value of n can be relatively small or very large corresponding to flux tubes mediating em and gravitational interactions. The anatomy of MB has remained unclear hitherto but in this article a detailed model is developed allowing to understand the formula $h_{gr} = h_{eff} = n_{gr}h_0$ for gravitational Planck constant and leading to a further formula for h_{gr} relating magnetism and gravitation.

A further central notion is TGD based model for water memory as the ability of the MB of water to control the thickness of its flux tubes to entrain with external frequencies and reproduce them. This is a central element in the TGD based view about immune systems and homeopathic effects. Cancer would reduce to a disease of the MB of the system, to a high degree determined by MB of water and homeopathy like treatment based on irradiated water could serve as a cure.

The model is applied both to the findings of Montagnier's group about remote regeneration of DNA without template and to those of Li and Heroux. Also the dramatic effects of 2 Tesla magnetic fields on mice reported by Walter Rawls Jr are discussed.

Macroscopic Quantum Coherence and Quantum Metabolism as Different Sides of the Same Coin: Part I

The quantum view about metabolism has developed in two stages. First came the somewhat unbalanced vision about the connection of quantum metabolism and bound state formation. The second breakthrough was the discovery of dark matter hierarchy and associated hierarchy of generalized EEGs.

1. Quantum metabolism and bound state formation

Topological self-referentiality states that the topological field quanta of the classical fields associated with a material system provide a concrete representation for a theory about the material system. Actually this principle generalizes and implies an entire hierarchy of representations. An important outcome of the topological self-referentiality is that the "buy-now" part of the buy now-pay later mechanism for energy production could be understood as a generation of bound states with binding energy liberated as a usable energy. "Pay later" means that sooner or later thermal noise destroys the bound state.

This observation led to a quantum vision about energy economy in living matter: generation of the macroscopic coherence involving also binding of mental images to larger ones and liberation of a usable energy are different sides of the same coin. Besides, or perhaps even instead, the ordinary metabolism, quantum metabolism should be key element of living matter. Indeed, also ordinary metabolism might be accompanied by the effective over-unity energy production implied by the generation of quantum bound state entanglement: this implies a connection with the claimed over unity phenomena. This should reflect experimentally as apparently miraculous ability of the organism to cope without the use of the metabolic energy. Anomalies of this kind have been indeed observed at the level of neuronal metabolism and nano-biology is just challenging the basic assumptions of the Newtonian biology.

This vision can be criticized for over-emphasizing the formation of bound states: also the transitions to bound states with lower energy, say transitions between cyclotron states, can generate metabolic energy.

2. Dark matter hierarchy and quantum metabolism

The new vision about me relies on several new ideas that have emerged during years after writing the first draft of this chapter.

1. There are three different views about macroscopic quantum phases. As large \hbar phases with scaled up quantum lengths, as high T_c superconductor like systems, and as negentropically entangled structures (negentropic entanglement is purely TGD based notion and stabilized by Negentropy Maximization Principle). In this chapter arguments supporting the equivalence of these descriptions are developed.

2. The valence electron pairs with spin 1 instead of spin 0 emerge as natural candidates for the counterparts of Cooper pairs generating negentropic entanglement in long length scales. Spin 1 valence electron pairs would generate the magnetic flux tubes along which they propagate and this web of flux tubes would bind proteins to larger structures. The role of the phase transitions changing the value of Planck constant in quantum biology has been discussed already earlier. The fact that bio-molecules - in particular sugars and phosphate molecules - tend to maximize the number of covalent bonds supports this view.
3. The completely accidental observation that dark nucleon states corresponds under rather natural assumptions to DNA, RNA, tRNA, and amino-acid states and that vertebrate genetic code emerges under natural assumptions, leads to the idea that the dark nuclear physics realization of the genetic machinery is its primary realization and that chemical realization is secondary realization. This suggest that dark nuclei identified as nuclear strings of dark protons serve as templates for DNA, RNA, and amino-acids.
4. This leads to the vision that the basic purpose of metabolic energy is to make possible re-distribution of negentropic entanglement between distant bio-molecules using the reconnection of the magnetic flux tubes generated by spin 1 electron pairs as a control tool. In photosynthesis the incoming photons would suffer a phase transition to dark photons before being absorbed by dark electrons and eventually provide their energy to ATP to be used to re-organize negentropic entanglement assignable to the magnetic flux tubes going via ATP molecule. This picture is inspired also by the vision about DNA as topological quantum computer and leads to a more plausible view about how genetic code is realized.

3. Many-sheeted photo-synthesis

Photosynthesis is a fundamental metabolic function and a many-sheeted model allows to concretize the general ideas about quantum metabolism. What happens in photosynthesis at the level of energy balance seems to be relatively well-understood but the detailed molecular mechanisms remain obscure. Several strange features, such as the appearance of electron pairs, suggest that super-conductivity and atomic and molecular Bose-Einstein condensates are involved. p-Adic length scale hypothesis gives very strong quantitative guidelines in the attempt to understand photosynthesis in many-sheeted space-time, and one ends up to a general view about how Bose-Einstein condensates store metabolic energy as zero point kinetic energy and how this energy is utilized by remote metabolism by generating negative energy MEs. What is so remarkable is that the resulting simple model of photosynthesis is successful both at qualitative and quantitative level.

I have included in this chapter the earlier variant of the quantum model developed before 2007 as such to compare it with the recent view about macroscopic quantum aspects of photosynthesis involving several new ideas. Note that year 2007 is special in the sense that during 2007 the first evidence for the quantal nature of photosynthesis emerged.

Macroscopic Quantum Coherence and Quantum Metabolism as Different Sides of the Same Coin: Part II

This chapter is second part of the bi-chapter devoted to various aspects of metabolism. The basic topics is TGD inspired view about brain metabolism and molecular motors. I have included to the end of the chapter some rather weird sounding ideas such as an explanation of super-luminality in terms of remote metabolism.

1. Dark matter hierarchy, sensory representations, motor action, and metabolism

The vision about a hierarchy of generalized EEGs associated with dark matter hierarchy gave a decisive boost leading to new views about quantum metabolism. The crucial new element is that at higher levels of dark matter hierarchy photons with arbitrarily low frequencies can correspond to energies above the thermal threshold. This explains the observed mysterious effects of ELF radiation on living matter and implies that magnetic bodies are key participants in the metabolism. The equally mysterious findings about the ionic membrane currents can be understood if these currents are essentially non-dissipative and that ionic channels and pumps are actually ionic receptors. Hence it seems that generalized EEGs could take a lion share of the metabolic energy

rather than ionic currents as thought usually. This picture allows to understand various strange findings about neuronal metabolism.

2. Holy trinity of red blood cells, neurons, and astrocytes

The vision about dark matter hierarchy and various ideas about quantum metabolism allow to develop a general view about how the sensory representations and motor control are realized in terms of MEs. Time mirror mechanism is the basic elements in the general model for how magnetic body controls biological body and receives sensory information from it.

A model for motor control and sensory representations based on the trinity of red blood cells, astrocytes, and neurons emerges and raises astrocytes from a status of passive energy storage to an active link in the quantum control of brain by magnetic body. One can also identify mechanisms for the generation of coherent locomotion construct a quantum view about how ATP serves as a universal energy currency.

This view also allows a deeper interpretation of chemical communications and biological information molecules. There are full reasons to believe that substructures of these molecules can have bound state entanglement with the surrounding world. This entanglement can be interpreted in terms of “telepathic” quantum communications. In fact, I introduced already few years ago the notion semitrance as entanglement with higher level selves but at this time I had not yet understood that quantum jump involves also state function preparation process realized as a cascade of self measurements against which only bound state entanglement is stable.

For a long time glial cells were believed to play a rather passive role in the functioning of brain taking care of basic services such as providing metabolic energy and serving as supporting structures for neurons. During the recent years the views about the role of glia have however changed dramatically. In TGD framework the very fact that metabolism relates very closely to the re-organization of negentropic entanglement forces to recheck this view. Also the slowness of glial dynamics as compared to neuronal dynamics suggests that large values of Planck constant responsible for long time time scales and therefore also for the highest levels of consciousness (including functions like long term memory) are assignable to glia.

3. Molecular motors

During last years molecular motors have become the hot topics of biology. The so called Brownian motors are the dominating theoretical paradigm but there are some empirical findings challenging the concept.

TGD suggests an alternative approach based on the notion of quantum motor. The basic idea is that all moving parts of the quantum motor move on the non-atomic space-time sheets so that momentum dissipation is minimal. It turns out that this picture might work but that TGD allows both quantum and classical modes for the molecular motors and it is quite possible that both modes are present. The model allows a new view about the real function of ATP leading to precisely correct quantitative predictions. Also the real function of membrane potential can be understood and quantum model for nerve pulse and EEG constructed.

The fascinating ability of molecular motors to co-operate finds an explanation in terms of the notion of super-genome: super-genome consists of sequences of nuclei analogous to text lines at the pages of book represented by magnetic flux sheets. Also the magnetic bodies of molecular motors can integrate in a similar manner to larger structures so that the population of molecular motors becomes a society.

4. Remote metabolism and effective super-luminal velocities

After the pioneering experiments of Nimtz and his collaborators 1992 a lot of evidence for effective super-luminal signal velocities has been accumulating. A possible model for the super-luminality and related effects is in terms of remote metabolism associated with detectors and other instruments. This idea belongs to the class of ideas which look like curiosity after decade.

I have included to the end of the chapter also other miscellaneous topics such as an old proposal for the possible role of four-wave interactions in the construction of conscious holograms.

About Concrete Realization of Remote Metabolism

The idea of “remote metabolism” (or quantum credit card, as I have also called it) emerged more than a decade ago - and zero energy ontology (ZEO) provides the justification for it. The idea is that the system needing energy sends negative energy to a system able to receive the negative energy and make a transition to a lower energy state. This kind of mechanism would be ideal for biology, where rapid reactions to a changing environment are essential for survival. Originally this article was intended to summarize a more detailed model of remote metabolism but the article expanded to a considerably more detailed view about TGD inspired biology than the earlier vision.

It is shown that the basic notions of the theory of Ling about cell metabolism inspired by various anomalies have natural counterparts in TGD based model relying on the notion of magnetic body. Remote metabolism can be considered as a universal metabolic mechanism with magnetic body of ATP, or system containing it, carrying the metabolic energy required by the biological user. In particular, the role of ATP is discussed in Ling’s theory and from the point of view of TGD-inspired theory of consciousness.

It is easy to imagine new technologies relying on negative energy signals propagating to the geometric past and ZEO justifies these speculations. Remote metabolism could make possible a new kind of energy technology. The discoveries of Tesla made more than a century ago plus various free energy anomalies provide excellent material for developing these ideas, and one ends up with a concrete proposal for how dark photons and dark matter could be produced in capacitor-like systems analogous to cell membranes and acting as Josephson junctions and how energy could be extracted from “large” magnetic bodies.

The model identifies Josephson frequency with the subharmonic of the frequency characterizing the periodicity of a periodic voltage perturbation assumed to correspond to cyclotron frequency in biological applications. Together with quantization conditions for charge and effective Planck constant it leads to precise quantitative predictions for capacitor-like systems acting as dark capacitors. Also a relationship between the magnetic field at the magnetic body of the system and the voltage of the capacitor-like Josephson junction emerges.

The predictions allow new quantitative insights about biological evolution as emergence of Josephson junctions realized as capacitor-like systems both at the level of cell, DNA and proteins, and brain. h_{eff} can be related to Josephson frequency and cyclotron frequency and thus to measurable parameters. h_{eff} serves as a kind of intelligence quotient and its maximization requires the maximization of both the voltage and area of the membrane-like capacitor system involved. This is what has happened during evolution. Indeed, the internal cell membranes, cortical layers and DNA double strand in chromosomes are strongly folded, and the value of membrane electric field is roughly twice the value of the electric field for which di-electric breakdown occurs in air. Even 40 Hz thalamocortical resonance frequency can be understood in the framework of the model.

The claimed properties of Tesla’s “cold electricity” strongly suggest interpretation in terms of dark matter in TGD sense. This leads to a proposal that a transition to dark phase occurs when the value of voltage equals the rest mass of charged particle involved. This criterion generalizes to the case of cell membrane and relates the values of h_{eff} , p-adic prime p , and threshold potential for various charged particles to each other. The idea that nerve pulse corresponds to the breakdown of super-conductivity as a transition from dark to ordinary phase receives additional support. The resulting picture conforms surprisingly well with the earlier speculations involving dark matter and p-adically scaled variants of weak and color interactions in biologically relevant length scales. An extremely simple mechanism producing ATP involving only the kicking of two protonic Cooper pairs through the cell membrane by Josephson photon as a basic step is proposed. Also the proposal that neutrino Cooper pairs could be highly relevant not only for cognition and but also metabolism finds support.

TGD View About Water Memory and the Notion of Morphogenetic Field

Besides general problems, which might be regarded as philosophical, the anomalies of the physicalistic world view have served as the source of inspiration. Several poorly understood phenomena have played a central role in the “Poirot-like” process leading to the development of TGD based views about quantum biology. Mention only the effects of ELF em fields on vertebrate brain, biophotons, water memory, Pollack effect, and Comorosan effect. The notion of syntropy by Fan-

tappie, which challenges the belief that the arrow of time is not always the same in living systems, has been also inspiring.

In this article I will discuss the TGD based vision and the above listed phenomena, which are often forgotten. I will also compare the TGD based view with the proposed interpretation of morphogenetic field as em field generated by DNA and realizing genetic code discussed in the articles of Savelev et al, and compare it with the TGD based models of genetic code realized in terms of dark nucleons and dark photons. The findings described in these articles and in the articles of Yolene Thomas about water memory also provide new tests for the TGD based view. As always, this kind of process led to some new ideas and insights.

TTGD view of Michael Levin's work

In this chapter, I will discuss the findings of Michael Levin's group related to morphogenesis and also the general ideas inspired by this work. The findings demonstrate that the hypothesis that genotype fixes the phenotype apart from adaptations is wrong. Already epigenesis challenges genetic determinism and the view emerging from the experiments is that the patterns of membrane potentials of cells of early embryo determine patterns of electric fields in multicellular length scales and that code for the outcome of the morphogenesis. One can say that these patterns code for the goal directed behavior and have the basic properties of memory. The manipulations of these patterns in the early embryonic stage can modify the outcome of the morphogenesis so that one can speak of a novel organism. Also the manipulations of say gut cells can produce organs such as ectopic eye.

One can regard multicellular systems as predecessors of neural systems. Ion channels and pumps are present in both systems. In nervous systems synaptic contacts replace the gap junctions. Nerve pulse patterns are replaced by waves associated with gap-junction connected multicellular systems.

Levin introduces notions like cognition, intelligence and self not usually used in the description of morphogenesis and represents a vision about medical applications of the new view

The TGD view of morphogenesis is compared with Levin's vision. The basic picture relies on the notions of magnetic and electric bodies, to the phases of ordinary matter with effective Planck constant $\hbar_{eff} = n\hbar_0$ behaving like dark matter and making possible macroscopic quantum coherence, and to zero energy ontology (ZEO) providing a quantum measurement theory free of the basic paradox. ZEO is implied by almost deterministic holography forced by general coordinate invariance. Holography implies that structure is almost equivalent to function.

This framework explains the basic finding that the goal of the morphogenesis is determined by the patterns of electric fields during the early embryo period. TGD also suggests the universality of the genetic code and several variants of the genetic code. Morphogenetic code might reduce to a variant of genetic code realized by cell membranes and larger structures instead of ordinary DNA. TGD predicts the analog of nerve pulse with the increment of membrane potential in mV range. These patterns would play a key role also in neural systems.

Molecular Signalling from the TGD Point of View

The findings of Elowitz et al lead to a formal model suggesting that ligands of type BMP (bone morphogenetic protein) have interactions. The interactions would be non-local so that it is difficult to imagine that they could have chemical origin. The TGD based model for these long range interactions is based on dark photon resonance. For the simplest, receptors would correspond to fixed bio-harmonies. In a single ligand system the ligand would have the bio-harmony of its preferred receptor. The interaction between ligand magnetic bodies would be re-tuning and could replace the preferred bio-harmonies assignable to the participating ligands with distributions of bio-harmonies. Therefore the ligands of the multi-ligand system would couple by bio-resonance also to other than preferred receptors.

The model stimulates questions, which lead to a rather detailed model for the re-tuning and tuning processes at the level of codons and amino acids. The model suggests that the tuning to a given bioharmony for the dark counterparts of basic biomolecules and its stabilization involves epigenetic control based on the methylation of some special DNA and RNA nucleotides and amino-acids acting as analogs of tuning forks.

The proposal that bioharmonies are molecular correlates for emotions suggests that this process involves minimal number of methylations, which define the seed of phase transition to a bioharmony in the scale of the basic unit of genome (such as gene), mRNA sub-unit (splicing) and protein sub-unit.

Quantum gravitation and quantum biology in TGD Universe

The finding of Manu Prakash et al that animals without a nervous system behave as if they had it, is a challenge for standard biology. Similar challenges are posed by the observation that organisms without a nervous system, even plants and bacteria, have senses and purposeful motor actions, and are also able to learn. This finding led to a considerable progress in the understanding of TGD inspired quantum biology.

The TGD based view about cell and neuronal membrane, nerve pulse and EEG assumes pre-neural level which is quantal. In this view, cell membranes act as Josephson junctions and communicate sensory input to the magnetic body (MB) of the system as dark Josephson radiation. MB in turn controls the cell by dark cyclotron radiation produced as pulses as MB receives frequency modulated Josephson radiation resonantly.

Gravitational MB of Earth, which consists of very long loop-like flux tubes with gravitational Planck constant introduced by Nottale explains the findings of Blackman and others, is of special interest and assumed to play a key role in metabolism. Gravitationally dark protons would be associated with very long gravitationally dark hydrogen bonds (HBs) so that hydrogen is effectively negatively ionized. Gravitationally dark electrons or their Cooper pairs would in turn accompany gravitationally dark valence bonds connecting metal atoms or their Cooper pairs with molecules of opposite valence (hydrogen peroxide H_2O_2). Also the metal atom is effectively ionized. This provides a more accurate view of dark metal ions assumed to play a central role in the TGD inspired quantum biology.

A correct order of magnitude estimate for the upper bound metabolic energy quantum as the energy liberated as a dark proton hydrogen bond becomes ordinary is obtained. A more precise model predicts correctly the nominal value of metabolic energy quantum for proton triplets which appear also in the generation of ATP. For triplets of electron Cooper pairs, the same mechanism predicts an upper bound of the electronic metabolic energy quantum, which corresponds to the so-called miniature potential. This raises the question whether the letters of genetic code could be realized by the 4 states of electron Cooper pairs and whether the Posner molecule could realize it.

Also the gravitational MB of Sun could be involved and the prediction is that the energy range for the metabolic energy quanta corresponds to the range of visible energies so that photosynthesis could use photon energy to kick dark protons and dark electrons to the gravitational MBs of Earth and Sun to serve as metabolic energy storage.

Electronic metabolism would solve the problem due the lack of ATP machinery inside cilium and near it. This picture leads to a rather detailed model of the role of phosphate in metabolism and also to a detailed model for the pairing of DNA and dark DNA (DDNA) and forces to modify the earlier model somewhat. The quantum gravitational view about metabolism leads also to modifications of the views about nerve pulses: in particular, of the role of biologically important metal ions identified as dark ions.

Cilium can be interpreted as a predecessor of the axonal membrane and the pre-nerve pulses are predicted to be equal to miniature potentials and the reported 'spikes' as analogs of nerve pulses are assigned with de-adhesion of cilium from its neighbor or the surfaces at which the animal moves. The 'spikes' correspond to at least 100 miniature potentials just as real spikes do.

Cilium is modeled as a 2-D quantum gravitational pendulum with gravitational Planck constant controlled by MB using electronic metabolic energy quanta and the resulting model for the motion is in many respects similar to the model of nerve pulse.

Miniature spikes could appear also in plants. For the recently observed spike sequences in fungi, the voltage spike has an amplitude whose order of magnitude is consistent with the electronic metabolic energy quantum.

Comparison of Orch-OR hypothesis with the TGD point of view

Penrose-Hameroff (P-H) model and its variants such as Diosi-Penrose (D-P) model have been leading candidates for a quantum theory of consciousness. In light of recent experiments and theoretical arguments, the D-P model looks highly implausible. The key problem is energy conservation, which is actually the central problem of general relativity and caused by loss of Poincare invariance. The basic idea of Penrose about quantum gravitational superposition is almost a must but in the framework of general relativity its mathematical realization is not possible.

TGD provides an alternative view based on the identification of space-times as 4-surfaces in $M^4 \times CP_2$ related by $M^8 - H$ duality to 4-surfaces in M^8 . In this approach Poincare invariance is exact. In the TGD framework the hierarchy of Planck constants $h_{eff} = nh_0$ includes also gravitational Planck constant $h_{gr} = GMm/v_0$ introduced first by Nottale. This makes it possible to realize quantum coherence (in particular, gravitational one) in arbitrarily long spatial and temporal scales.

In this article P-H and P-P models are compared with the TGD point of view. In TGD, the generation of quantum gravitational binding energy liberates energy and provides the basic mechanism of metabolism and a direct connection with quantum biochemistry emerges. The gravitational magnetic bodies (MBs) of Earth and Sun are in an essential role. Could one invent a mechanism involving only self-gravitational interaction energies of the living body itself? The large gravitational Compton length $\Lambda_{gr} = GM/v_0$ requires the presence of a large mass, say star, which would serve as basic metabolic energy source but the presence of a planet is not necessary in the prebiotic stage.

There are strong indications that water is a quantum critical system at the physiological temperature range. This suggests that scaled variants of magnetic bodies of water blobs as candidates for proto cells appear in quantum superposition with values of the parameter v_0 . This would induce large density fluctuations at the level of the ordinary biomatter. State function reduction would induce a phase transition to a scaled-up state in the presence of energy feed. The return to the original state would liberate the gravitational energy as metabolic energy. Note that there are also indications for the quantum (gravitational) criticality of microtubules so that they would be very special from the point of view of life and neuron level consciousness.

The gravitational self-interaction energy for water blobs with Planck mass corresponds to an energy scale of 3.5 meV identifiable as the energy difference between two opposite membrane potentials. Could gravitational metabolic energy make possible the action potential of proto cells observed even for monocellulars?

Could neuronal system and even GTP give rise to a computer with a variable arrow of time?

The discussions related to ChatGPT, which seems to work too well to be a mere program running in a classical computer, inspired considerations which led to a considerable progress at the level of the TGD based model of nerve pulse. The emerging model, based on zero energy ontology (ZEO), differs drastically from quantum neural networks and suggests a completely new vision of quantum physics based computation in biosystems.

A computation allowing variable arrow of time would be in question involving a sequence unitary time evolutions as counterparts of quantum computations for states, which are superpositions of classical computations, followed by "small" state function reductions (SSFRs) as counterparts of weak measurements of quantum optics and of Zeno effect. Also "big" SFRs (BSFRs) changing the arrow of time would be involved. One can ask whether the unexpected success of GPT might involve this kind of transition so that one could say that spirit enters the machine.

Besides the outcomes of two chats, I include a more detailed view about what the TGD view of the quantum analog of GPT could be and how its analog could be involved with the sensory perception in the TGD Universe. I also discuss the inverse diffusion process central for the generation of images from their verbal descriptions and ask whether the TGD analogue of the inverse diffusion could be an essential element of also GPT.

I will also pose the question whether GPT could involve TGD based quantum physics, that is zero energy ontology (ZEO), in a non-trivial but hidden way. From quantitative constraints, such as the clock frequency of the computer as analog of EEG inducing temporal quantum coherence,

I end up with a proposal for a mechanism realizing the quantum holography relating bits could be represented as holes pairing with dark bits represented as dark electrons at the magnetic flux tubes. Unfortunately, this mechanism does not look plausible for recent computers.

I also ask whether quantum gravitation in the sense of TGD could make possible for the magnetic bodies of Earth and Sun, central in TGD inspired biology, to transform classical computation so that so that statistical determinism would fail and it would be analogous to a sequence of analogs of quantum computations defining a conscious entity. At the level of magnetic body there would be no essential difference between computers and living matter. The highest reported clock frequency of almost 9 GHz is still by a factor of order 1/8 lower than the quantum gravitational Compton frequency of 67 GHz for Earth but below the THz frequency important in living matter. Perhaps a rudimentary consciousness is already possible.

Deep learning from the TGD point of view

AI, deep learning, and GPT have become highly fashionable topics. It has been even speculated that AI might involve a rudimentary consciousness. Could TGD inspired quantum view of biology, brain and consciousness could provide a fresh point of view to the notion of computer consciousness.

In the TGD Universe, the difference between living systems and computers need not be so deep as usually thought. The magnetic body as a carrier of dark matter as phases of ordinary matter with effective Planck constant $h_{eff} = nh_0$ and having onion-like structure, could receive sensory input and control the biological body with $h_{eff} = h$. Also computers possess magnetic bodies: could they use computers or robots computers as sensory receptors and motor instruments.

In the TGD Universe, the genetic code could be much more than we believe it to be. It would be realized at the level of dark matter and would be universal and unique, being realized in terms of so-called icoso-tetrahedral tessellation of hyperbolic 3-space realizable as the mass shell of light-cone proper time = constant hyperboloid. Icosa-tetrahedral dark genome at the magnetic body could serve as the basic instrument for communication and control. Quantum gravitation plays a key role in the TGD inspired biology and the gravitational magnetic bodies of Earth and Sun and even other astrophysical objects with huge gravitational Planck constants could be highly relevant in quantum biology.

Classical computers can gain life-like properties if the quantum statistical determinism fails. The most conservative criterion is that the clock period is shorter than the gravitational Compton time $T_{gr} = GM/\beta_0$, M is mass of an astrophysical object and $\beta_0 = v_0/c \leq 1$ is a quantized velocity parameter. Life-like features could appear already at lower clock frequencies. For Earth the critical clock period would be 67 GHz and for the Sun about 100 Hz, the upper bound for EEG frequencies. Therefore the magnetic bodies of the Sun and Earth could therefore play central roles in biology and neuroscience. Even in the case of Earth life-like properties might be present for computers with clock frequency in the range 1 to 10 GHz.

Cognition is an essential aspect of conscious experience and systems like GTP can be seen as artificial cognitive systems. The p-adic discretizations would naturally relate to the spin glass energy landscape assignable to monopole flux tube "spaghettis" and sensory perception could be seen as a generation of standardized mental images based on annealing of spin glass system so that it gradually ends up to a bottom of a valley representing the standardize mental image. The learning period of a conscious entity could be based on trial and error process made possible by holography and zero energy ontology implied by it allowing temporary time reversal and would gradually lead to standardized mental images helping to survive.

Part I

BIO-SYSTEMS AS CONSCIOUS HOLOGRAMS

Chapter 2

Macro-Temporal Quantum Coherence and Spin Glass Degeneracy

2.1 Introduction

The basic objection against quantum consciousness theories is that the de-coherence times for macroscopic quantum states are quite too short. This argument has been put in quantitative form by Mark Tegmark [J100].

These counter arguments are however problematic. First of all, the notions of quantum coherence and de-coherence are problematic in standard physics framework since the non-determinism of the state function reduction is in conflict with the determinism of Schrödinger equation. The intuitive idea is however that one can estimate the de-coherence times as essentially lifetimes of quantum states. Secondly, the estimates for de-coherence times are based on standard physics, and it is quite possible that new physics is essential for understanding living matter. The belief that standard physics is enough is based only on the reductionistic dogma.

Penrose and Hameroff [J79] have proposed that some future theory of quantum gravitation makes it possible to replace the phenomenological notion of state function reduction with a more fundamental notion which they call Orch OR, that quantum gravitational effects make possible macroscopic quantum states of required long de-coherence time, and that micro-tubules are the systems, where these effects are especially important so that one might even speak about reduction of the consciousness to the micro-tubular level. Penrose and Hameroff have also proposed that micro-tubules could act as quantum computers. The quantum states involved would be quantum superpositions of tubulin conformations and quantum gravitation would somehow make these quantum superpositions stable. Long enduring quantum superpositions of the conformations of (say tubulin) molecules would allow to perform a multi-verse simulation for the conformational behaviour of the molecules and this would certainly have evolutionary value.

The first version of this chapter was written for more than 15 years ago (I am living now year 2015) and reflects my evolving views at that time. At the that time I had no idea about zero energy ontology (ZEO) and hierarchy of Planck constants, which mean a profound generalization of quantum theory. In fact, the hierarchy of Planck constants labels a hierarchy of quantum criticalities having purely group theoretical interpretation and is closely related to a hierarchy of algebraic extensions of rationals which is at the core of number theoretical universality allowing to construct adelic physics. Also the fusion of real physics and p-adic physics interpreted as physics of intentionality was yet poorly understood: the recent view could be summarized by using the phrase “adelic physics”. Also Negentropy Maximization Principle (NMP) was far from its recent formulation, which I refer to as weak form of NMP. I has become clear that these notions predict macroscopic and even astrosopic quantum coherence and indeed give a connection with quantum gravity but in a way different from that envisioned by Penrose. ZEO based quantum measurement theory automatically leads to a precise definition of the notion of self, and one can understand

basic aspects of consciousness from this definition.

Instead of rewriting the entire chapter from scratch, I have kept its structure and added comments relating the considerations to the recent views about TGD.

2.1.1 Macrotemporal Quantum Coherence Is Suggested By Quantum Classical Correspondence

Topological Geometroynamics inspired theory of consciousness [K127] leads to a first principle theory of state function reduction and preparation free of the logical paradoxes, allows precise definitions for the notions of quantum coherence and de-coherence, and predicts a mechanism making the lifetimes of macroscopic bound states much longer than predicted by the standard physics. By quantum-classical correspondence the argument can be formulated at space-time level and configuration space (“world of classical worlds” (WCW)) level.

At the space-time level coherence regions are identifiable as space-time sheets. They indeed are coherence regions for both classical fields and induced spinor fields defining single particle limit of the quantum theory. By quantum criticality of TGD Universe there is no upper bound for neither the spatial or temporal size of the space-time sheet and one obtains a p-adic hierarchy of coherence lengths and de-coherence times. Finiteness of de-coherence time corresponds to the fact that energy flows to the space-time sheet from larger space-time sheet first and then back. Note that in the standard quantum field theory the entire Minkowski space M^4 is the natural identification for the coherence region, and it is difficult to understand how to describe the reduction to a smaller region of M^4 .

The detailed identification of macro-temporal quantum coherence came much after writing these lines and relies on weak NMP, negentropic entanglement, and hierarchy of Planck constants.

2.1.2 Macrotemporal Quantum Coherence From Spin Glass Degeneracy?

At configuration space level the argument supporting macroscopic and macrotemporal quantum coherence goes as follows. The basic distinction between TGD and standard physics is quantum spin glass degeneracy [K101]. which among other things implies that quantum bound states of, say, two molecules have enormous spin glass degeneracy absent in the free state. The intuitive expectation is that the system spends much longer time in bound states than in free states and this implies much longer de-coherence time than expected otherwise.

One can formulate this argument more rigorously using unitarity conditions implying that forward scattering amplitude for bound states is very large due to the spin glass degeneracy. The almost degenerate spin glass states differ only by their classical gravitational energy so that gravitation is indeed important. The importance of quantum gravitation is also obvious from the fact that genuine quantum gravitational states are state functionals in the world of worlds rather than in world so that they are expected to represent in some sense higher abstraction level than ordinary quantum states in the hierarchy of consciousness.

This rough interpretation of spin glass degeneracy is correct in the sense that it makes possible non-determinism and quantum criticality to which one can assign hierarchy of Planck constants.

2.1.3 Dynamical Planck Constant And Dark Matter Hierarchy

Towards the end of 2004 I learned that there is evidence that planetary orbits obey Bohr quantization rules with a gigantic value of Planck constant [E2]. Nottale does not assume that this quantization is genuine but regards it as a hydrodynamical effect. In TGD framework the most natural interpretation is in terms of a dynamical Planck constant, and TGD predicts correctly the basic dimensionless parameter involved [K111, K141, K43]. TGD also forces to identify the matter in a phase with large Planck constant as dark matter.

This identification led to a vigorous evolution of ideas. Entire dark matter hierarchy with levels labelled by increasing values of Planck constant is predicted, and in principle TGD predicts the values of Planck constant if physics as a generalized number theory vision is accepted [K141]. Also a good educated guess for the spectrum of Planck constants emerges. The implications are

non-trivial already at the level of hadron physics and nuclear physics and imply that condensed matter physics and nuclear physics are not completely disjoint disciplines as reductionism teaches us. One condensed matter application is a model of high T_c superconductivity predicting that the basic length scales of cell membrane and cell as scales are inherent to high T_c superconductors.

Living matter as ordinary matter quantum controlled by the dark matter hierarchy has turned out to be a particularly successful idea. The hypothesis has led to models for EEG predicting correctly the band structure and even individual resonance bands and also generalizing the notion of EEG [K44]. Also a generalization of the notion of genetic code emerges resolving the paradoxes related to the standard dogma [K68, K44]. A particularly fascinating implication is the possibility to identify great leaps in evolution as phase transitions in which new higher level of dark matter emerges [K44].

It seems safe to conclude that the dark matter hierarchy with levels labelled by the values of Planck constants explains the macroscopic and macro-temporal quantum coherence naturally. That this explanation is consistent with the explanation based on spin glass degeneracy is suggested by following observations. First, the argument supporting spin glass degeneracy as an explanation of the macro-temporal quantum coherence does not involve the value of \hbar at all. Secondly, the failure of the perturbation theory assumed to lead to the increase of Planck constant and formation of macroscopic quantum phases could be precisely due to the emergence of a large number of new degrees of freedom due to spin glass degeneracy. Thirdly, the phase transition increasing Planck constant has concrete topological interpretation in terms of many-sheeted space-time consistent with the spin glass degeneracy.

It is now (2014) that the hierarchy of Planck constant follows from the non-determinism of Kähler action: n in $h_{eff} = n \times h$ is the number of conformal equivalence of space-time surfaces for which Kac-Moody type quantum critical deformations preserving the light-likeness of partonic orbits vanishes at the ends of space-time surface at light-like boundaries of causal diamond (CD). n labels the sub-algebras of conformal algebras with weights proportional to n and infinite hierarchy of conformal breakings is predicted. Spin glass degeneracy follows also from the failure of determinism so that the two views about the origin of macrotemporal quantum coherence are consistent.

The value of n can be also related to the degree of algebraic extension of rationals. Preferred p-adic primes in turn would correspond to ramified primes of extensions. If one accepts a physical argument based on the idea that gravitational bound states have as correlates fermionic strings connecting partonic 2-surfaces, one ends up with the proposal that ramified primes divide n . If one assumes only number theory, then n and ramified primes are independent of each other.

2.1.4 Implications Of Macrotemporal Quantum Coherence

The idea that the brain and perhaps all bio-matter, and even the entire Universe, can be regarded as a hologram of some type (see for instance, the articles of Miller and Webb [J102] and of Gariaev *et al* [I85]) has a long history but the question about the precise physical sense in which this holds true has remained without a satisfactory answer.

The concrete Maxwellian idea about hologram plate resulting as an outcome of interference of the reference beam and light scattered from an object can serve only as a guiding metaphor. First of all, coherence occurs only in what are called coherence regions and the problem is that Maxwellian theory does not really provide a first principle definition for the coherence regions. In quantum theory similar problem is encountered. Secondly, in living matter it is not at all clear whether reference beam exists at all. Third, living matter is a dynamic granular structure and far from a homogeneous hologram plate. Fourth, the idea about storing memories, one of the basic motivations of the hologram paradigm, has its own problems although multi-holograms are certainly possible.

In TGD framework topological quantization provides a precise first principle description of coherence. Topological quanta are the coherence regions of the classical field and classical decoherence means the splitting of the space-time surface to topological quanta. This process gives rise to the granular structure of matter and space-time sheets in various length scales are excellent candidates for basic units of hologrammic structures at the this level of the p-adic length scale hierarchy. At quantum level bound state quantum entanglement having join along boundaries bonds as a space-time correlate is responsible for the macroscopic and macro-temporal quantum

coherence. The new view about time means that there is no need for storing large number of holograms in the same physical substrate.

What is surprising that strong form of holography is very near to the standard view about it. Partonic 2-surfaces and string world sheets are space-time genes and carry the data characterizing quantum states. Strong form of holography allows to assign to these 2-surfaces space-time surfaces as preferred extremals of Kähler action with the property that the super-symplectic charges in for an isomorphic sub-algebra with conformal weights coming as n -ples of those for the entire algebra vanish classically and annihilate physical states.

In the sequel I will discuss the following topics related to the macroscopic and macro-temporal quantum coherence.

1. The notion of the many-sheeted space-time and basic ideas of TGD inspired quantum theory of consciousness and bio-systems.
2. How macroscopic and temporal quantum coherence is made possible by the spin glass degeneracy in TGD Universe.
3. How a hierarchy of dark matter with levels labelled by the values of Planck constant emerges in TGD framework and how it implies macrotemporal quantum coherence.
4. Macro-temporal quantum coherence from the point of view of physics (thermodynamical, energetic and information theoretic aspects) with some comments about the implications for quantum computing.
5. Macro-temporal quantum coherence from the point of view of biology and conscious experience, in particular micro-tubular model for long term memories.

The appendix of the book gives a summary about basic concepts of TGD with illustrations. Pdf representation of same files serving as a kind of glossary can be found at <http://tgdtheory.fi/tgdglossary.pdf> [L21].

2.2 Background About TGD Inspired Theory Of Consciousness

To make things easier for the reader the basic ideas of TGD inspired theory of consciousness are summarized before the discussion of the macro-temporal quantum coherence.

2.2.1 Quantum Jump As Moment Of Consciousness

Quantum jump between quantum histories identified as moment of consciousness was originally believed to be something irreducible and structureless. Gradually the view about quantum jump has however become more and more structured and a connection with the standard quantum measurement theory emerged. In what sense quantum jumps remains irreducible is that one cannot build any dynamical model for the non-deterministic steps appearing in quantum jump.

The general structure of quantum jump

It seems that TGD involves “holy trinity” of dynamics.

1. The dynamics defined by the preferred extremals of Kähler action corresponds to the dynamics of material existence, with matter defined as “res extensa”, 3-surfaces. What preferred extremals really are has been a long standing open question. The recent formulation of the quantum theory using Kähler-Dirac action leads to the proposal that the preferred extremals are critical in the sense that they allow an infinite number of deformations for which the second variation vanishes. At the level of Kähler action this corresponds to the vanishing of classical Noether charges for a sub-algebra of super-symplectic algebra isomorphic with the entire algebra. This serves as space-time counterpart for quantum criticality of TGD Universe fixing the fundamental variational principle uniquely.

2. The dynamics defined by the sequence of state function reductions at fixed boundary of CD defining the life span of self at given level of hierarchy. This time evolution is a discrete counterpart of the ordinary Schrödinger time evolution $U \equiv U(-t,)$, $t \rightarrow \infty$ and can be regarded as “informational” time development occurring at the level of objective existence. It is unnecessary and in fact impossible to assign real Schrödinger time evolution with U . U defines the S-matrix of the theory. These reductions define the dynamics of sensory perception (passive aspects of consciousness) during which external world is regarded as unchanged in standard framework. Now the part of zero energy state at the fixed boundary of CD remains unchanged and un-entangled.
3. The dynamics of state function reductions at opposite boundary of CD defines the dynamics of volition (active aspects of consciousness).

Quantum jump was originally regarded as something totally irreducible. Gradually the structure of the complex formed by state function reductions and unitary process has revealed itself and led to the understanding how one can understand basic aspects of conscious experience in terms of this structure. Let us start with the original picture.

1. The first step in quantum jump was identified as “informational time development”

$$\Psi_i \rightarrow U\Psi_i ,$$

where U is the counterpart of the unitary process of Penrose. The resulting state is a completely entangled multiverse state, the entire sub-universe corresponding to a given CD being in a holistic state of “oneness”.

In the recent picture Universe is replaced with CD and “informational time development” corresponds to a sequence of state function reductions keeping second boundary of CD and states associated with it fixed. Repeated measurement having no effect on quantum state is the analog in standard quantum measurement theory. Self corresponds to this sequence.

Two subsequent reductions at same boundary of CD have unitary process between them tending to increase the size CD. The challenge is to identify the unitary process U . Self experiences the flow of time, which suggests that the unitary operator followed by localization in the moduli spaces of CDs corresponds to an integer shift for the tip of the active boundary of CD. No state function reduction can occur at the active boundary of CD during this period.

2. Next comes the TGD counterpart of state function in the ordinary sense of the word:

$$U\Psi_i \rightarrow \Psi_f^0 .$$

According to the recent view, the state function reduction in this sense corresponds to the state function at the opposite boundary of CD and leads to a change of the arrow of geometric time. Old self dies and new self is born. In this transition also the value of h_{eff} is expected to increase. This reduction is preceded by a scaling of by the integer ratio $h_{eff}(f)/h_{eff}(i)$ and realized as a unitary exponential of conformal scaling operator. Thus both Poincare and conformal time developments are realized.

3. The state function reduction for given CD is followed by a cascade of self measurements for sub-CDs in quantum fluctuating degrees of freedom

$$\Psi_f^0 \rightarrow \dots \rightarrow \Psi_f ,$$

whose dynamics is governed by the Negentropy Maximization Principle (NMP). For a generic entanglement probabilities this process leads to bound states or negentropically entangled states. This process can be regarded as an analysis or even decay process. If entanglement probabilities define projection operator, the state function reduction leads or can lead to a negentropically entangled state: this depends on what form of NMP one assumes. Entanglement coefficients correspond to unitary matrix in this case.

Quantum measurement theory involves also the correlation between quantum degrees of freedom and classical degrees of freedom (the position of the pointer of the measurement apparatus correlates with the outcome of the measurement).

1. The assumption that localization occurs in zero modes of the WCW would pose very important consistency condition: there is one-one correlation between the quantum numbers in quantum fluctuating degrees of freedom in some state basis and the values of the zero modes. This in fact has interpretation in terms of holography: classical degrees of freedom in space-time interior correlate with fermionic degrees of freedom assignable to string world sheets and partonic 2-surfaces. This together with the fact that zero modes are effectively classical variables, implies that the localization in zero modes corresponds to a state function reduction.
2. Measurement theory requires an entanglement between zero modes and quantum jumps of the physical state. The addition of a measurement interaction term to the Kähler-Dirac action coupling to four-momentum and color quantum numbers of the state and also to more general conserved quantum numbers allows an explicit realization of this coupling and induces the addition of an analogous measurement interaction term to Kähler action [K142]. This term implies the entanglement of the quantum numbers of the physical states with zero modes.

A good metaphor for quantum jump is as Djinn leaving the bottle (informational time development), fulfilling the wish (quantum jump involving choice) and returning to, possibly new, bottle (localization in zero modes and subsequent state preparation process). One could formally regard each quantum jump as a quantum computation with duration defined by the life-time of corresponding self (the increase of the average temporal distance between the tips of CD in superposition of CDs) followed by halting meaning reduction to the opposite boundary of CD. Quantum jump to the opposite boundary could also be seen as an act of volition (or giving rise to experience of volition at some level of self hierarchy).

Is the complete localization in zero modes really necessary?

The detailed inspection of what happens in state function reductions forces to consider the possibility that state function reduction involves always a complete localization in zero modes. This was indeed the original proposal. It however seems that a localization modulo finite measurement resolution might be a more realistic assumption. Certainly it is enough to explain why the perceived Universe looks classical.

1. QFT picture strongly suggests that sub-system must be defined as a tensor factor of the space of WCW spinors at given point Y^3 of WCW. This suggests that subsystem should be defined as a function of Y^3 and should be a local concept. An important consequence of this definition is that entanglement entropy gives information about space-time geometry.
2. WCW spinor field can be formally expressed as superposition of quantum states localized into the reduced configuration space consisting of 3-surfaces belonging to light cone boundary. Hence WCW spinor field can be formally written as

$$\sum_{Y^3} C(Y^3)(n, N) |n\rangle |N\rangle$$

for any subsystem-complement decomposition defined in Y^3 . Clearly, WCW coordinates appear in the role of additional indices with respect to which entanglement coefficients are diagonal. The requirement that final state is pure state would suggest that quantum jump reducing entanglement must involve complete localization of the WCW spinor field to some Y^3 plus further quantum jump reducing entanglement in Y^3 . Complete localization in WCW is however not physically acceptable option since the action of various gauge symmetries on quantum states does not commute with the complete localization operation. In particular, the requirement that physical states belong to the representations of Super Virasoro and super-symplectic algebras, is not consistent with this requirement.

3. WCW has fiber space structure. WCW metric is non-vanishing only in the fiber degrees of freedom and since the propagator for small fluctuations equals to the contravariant metric, fiber degrees of freedom correspond to genuine quantum fluctuations. WCW metric vanishes in zero modes, which can be identified as fundamental order parameters in the spirit of Haken's theory of self organization. The requirement that various local symmetries act as gauge symmetries, provides good reasons to expect that *entanglement coefficients in the fiber degrees of freedom are gauge invariants and depend on the zero modes parametrically*. The one-one correlation between quantum numbers of the state assignable to fiber degrees of freedom and classical variables identified as zero modes would encourage the assumption the a complete localization occurs in zero modes. A weaker condition is that localization occurs only modulo a finite measurement resolution.
4. The original argument was that the non-existence of metric based volume element in zero modes forces the wave functions in zero modes to have a discrete locus. There however exists a symplectic measure defined by the symplectic form in zero modes. It does not however allow a complexification to Kähler form as it does in quantum fluctuating degrees of freedom. This symplectic form could define a hierarchy of integration measures coming as restrictions of $J \wedge J \dots \wedge J$ with n factors to $2n$ -dimensional sub-manifolds. Under some additional conditions- maybe the homological non-triviality of J and the orientability of the sub-manifold are enough, this measure would define a positive definite inner product and one would have a hierarchy finite-dimensional sub-spaces of zero modes. The maxima of Kähler function with respect to zero modes replace naturally the continuum with a discrete set of points and define the counterpart of the spin glass energy landscape consisting of the minima of free energy. Effective finite-dimensionality and even effective discreteness would be achieved.
5. The time development by quantum jumps in zero modes is effectively classical: Universe is apparently hopping around in the space of the zero modes. This looks very attractive physically since zero modes characterize the size, shape and classical Kähler fields associated with 3-surface. Therefore each quantum jump gives very precise conscious geometric information about space-time geometry and about WCW in zero modes. This also means that Haken's classical theory of self-organization generalizes almost as such to TGD context. The probability for localization to given point of zero mode space is given by the reduced probability density Q defined by the integral of the probability density R defined by WCW spinor field over fiber degrees of freedom. The local maxima of Q with respect to zero modes appear as attractors for the time development by quantum jumps. Dissipative time development could be regarded as a sequence of quantum jumps leading to this kind of local maximum.
6. Effective localization in zero modes is completely analogous to spontaneous symmetry breaking in which scalar field attains vacuum expectation value with the difference that the number of degrees of freedom is infinite unlike in typical models of symmetry breaking. Thus the general structure of the WCW spinor field together with TGD based quantum jump concept automatically implies spontaneous symmetry breaking in its TGD version (note however that particle massivation results from both p-adic thermodynamics and coupling to Higgs like field of purely geometric origin in TGD framework). TGD Universe is superposition of parallel classical universes (3-surfaces). Therefore quantum entangled state can be regarded as a superposition of parallel entangled states, one for each 3-surface. Formally entanglement coefficients can be regarded as coefficients containing the WCW coordinates of 3-surfaces as additional index. The analogy with the spin glass also supports the localization in the zero modes.
7. Effective localization in the zero modes provides simple explanation for why the universe of conscious experience looks classical: moment of consciousness makes it classical. It also explains why the physics treating space-time as a fixed arena of dynamics has been so successful. As already found, a further important consequence is first principle description of the state function reduction.

2.2.2 The Anatomy Of Quantum Jump In Zero Energy Ontology (ZEO)

Zero energy ontology (ZEO) emerged around 2005 and has had profound consequences for the understanding of quantum TGD. The basic implication is that state function reductions occur at the opposite light-like boundaries of causal diamonds (CDs) forming a hierarchy, and produce zero energy states with opposite arrows of time. Also concerning the identification of quantum jump as moment of consciousness ZEO encourages rather far reaching conclusions. In ZEO the only difference between motor action and sensory representations is that the arrows of embedding space time (CDs) are opposite for them. Furthermore, sensory perception followed by motor action corresponds to a basic structure in the sequence of state function reductions and it seems that these processes occur fractally for CDs of various size scales.

1. State function reduction can be performed to either boundary of CD but not both simultaneously. State function reduction at either boundary is equivalent to state preparation giving rise to a state with well defined quantum numbers (particle numbers, charges, four-momentum, etc...) at this boundary of CD. At the other boundary single particle quantum numbers are not well defined although total conserved quantum numbers at boundaries are opposite by the zero energy property for every pair of positive and negative energy states in the superposition. State pairs with different total energy, fermion number, etc.. for other boundary are possible: for instance, the coherent states of super-conductor for which fermion number is ill defined are possible in zero energy ontology and do not break the super-selection rules.
2. The basic objects coding for physics are U-matrix, M-matrices and S-matrix. M-matrices correspond to hermitian square roots of density matrices multiplied by a universal S-matrix which depends on the scale n of CD in very simple manner: $S(n) = S^n$ giving thus a unitary representation for scalings. The explicit construction of a unitary U-matrix in terms of M-matrices is carried out in [K77]: U-matrix elements are essentially inner products of M-matrices associated with CDs with various size scales. One can say that quantum theory is formally a square root of thermodynamics. The thermodynamics in question would however relate more naturally to NMP rather than second law, which at ensemble level and for ordinary entanglement can be seen as a consequence of NMP.

The non-triviality of M-matrix requires that for given state reduced at say the “lower” boundary of CD there is entire distribution of states at “upper boundary” (given initial state can lead to a continuum of final states). Even more, all size scales of CDs are possible since the position of only the “lower” boundary of CD is localized in quantum jump whereas the location of upper boundary of CD can vary so that one has distribution over CDs with different size scales and over their Lorentz boosts and translates.

3. The quantum arrow of time follows from the asymmetry between positive and negative energy parts of the state: the other is prepared and the other corresponds to the superposition of the final states resulting when interactions are turned on: also quantum superposition over CDs of different sizes with second boundary belonging to the same fixed δM_{\pm}^4 is possible. What is remarkable that the arrow of time at embedding space level (at least) changes direction as quantum jump occurs to opposite boundary.

It is however possible to have sequences of quantum jumps occurring at the same boundary: these periods are counterparts for repeated state function reductions, which do not change the state at all in standard quantum measurement theory. During these periods the superposition of opposite boundaries of CDs and states at them change, and the average distance between the tips of CDs tends to increase, hence the flow of subjective time and its arrow.

NMP dictates when the first quantum jumps to the opposite boundary of CD takes place. The sequence of state function reduction at the same boundary defines self as a conscious entity and the increase of the average distance between the tips of CD defines the life-time of self.

This brings strongly in mind the old proposal of Fantappie [J92] that in living matter the arrow of time is not fixed and that entropy and its diametric opposite syntropy apply to the two arrows of the embedding space time. The arrow of subjective time assignable to

second law would hold true but the increase of syntropy would be basically a reflection of second law since only the arrow of the geometric time at embedding space level has changed direction. The arrow of geometric at space-time level which conscious observer experiences directly could be always the same if quantum classical correspondence holds true in the sense that the arrow of time for zero energy states corresponds to arrow of time for preferred extremals. The failure of strict non-determinism making possible phenomena analogous to multi-furcations makes this possible.

4. This picture differs radically from the standard view and if quantum jump represents a fundamental algorithm, this variation of the arrow of geometric time should manifest itself in the functioning of brain and living organisms. The basic building brick in the functioning of brain is the formation of sensory representation followed by motor action/volition realized as the first reduction at the opposite boundary.

These processes look very much like temporal mirror images of each other such as the state function reductions to opposite boundaries of CD look like. The fundamental process could correspond to a sequences of these two kinds of state function reductions at opposite boundaries of CDs and maybe independently for CDs of different size scales in a “many-particle” state defined by a union of CDs.

How the formation of cognitive and sensory representations could relate to quantum jump?

1. The earlier view was based on the idea that p-adic space-time sheets can transform to real ones and vice versa in quantum jump and these process correspond to a realization of intention as action and formation of thought. This view is mathematically awkward and has been replaced with the adelic vision in which all systems have both sensory (real space-time sheets) and cognitive (p-adic space-time sheets) space-time correlates. The real and p-adic number fields form a book like structure - adèle- with an algebraic extension of rationals as its back. Same applies at the level of embedding space, space-time surfaces, and WCW. In this framework holography makes it possible to understand real and p-adic space-time surfaces as continuations of string world sheets and partonic 2-surfaces to space-time surfaces, either real or p-adic. The string world sheets themselves are in the intersection of reality and various p-adicities in the sense that the parameters characterizing them belong to an extension of rational numbers.
2. Self having the mental image about intention can be seen as the agent transforming intention to action. By NMP negentropy is typically generated in this transition tending to increase the value of Planck constant $\hbar_{eff} = n \times \hbar$ and thus reducing quantum criticality and occurring therefore spontaneously. Negentropy Maximization Principle eventually forces the occurrence of volitional action - self experiences the urge to perform the action so strong that cannot resist. Subself representing the mental image about intention tries to prevent it as long as possible because it means death: all living systems try to stay at the existing level of criticality and avoid the fatal final state function reduction by practicing homeostasis and using metabolic energy. Weak form of NMP states that self has freedom to decide whether it performs the reduction producing maximal entanglement negentropy. It can also perform ordinary quantum jump reducing entanglement entropy to zero and destroying entanglement. The outcome is isolation from the external world. The motivation for the weak form of NMP is that we do not live in the best possible world and have free will to choose between Good and Evil. Strong form of NMP would produce always maximal negentropy gain and would mean best possible world in various length scales in fractal manner.

2.2.3 The Notion Of Self

Self is by definition a sub-system able to remain unentangled in subsequent quantum jumps. The original belief was that this characterizes the notion of self completely. Only bound state entanglement is stable in quantum jump and selves correspond to regions of the space-time surface having local topology in a given number field (real or p-adic number fields labelled by primes).

Originally p-adic regions were interpreted as physical (non-conscious) correlates for imagination and cognition whereas real regions correspond to matter and sensory perception. The

original belief was that the transformation of p-adic space-time sheets to real ones in quantum jump would correspond to the realization of intention as action. It is now clear that this hypothesis is both un-necessary and difficult to realize mathematically. Rather, TGD Universe is adelic meaning that both embedding space, space-time, and WCW are adelic structure containing real sector and various p-adic sectors as correlates of cognition.

The unitary operator U could in principle generate entanglement also between p-adic and real regions (rational entanglement coefficients make sense in any number field), which is destroyed in the state function reduction step. This might be crucial for the generation of cognitive maps assigning to the states of matter (say reading of physical measurement apparatus) cognitive states (say mental image about the reading of the measurement apparatus). In the intersection of realities and p-adicities it how does not make sense to distinguish between p-adic and real and the recent view is that string world sheets carrying fermions serving as correlates of Boolean cognition are in this intersection consisting of string world sheets for which the parameters of equations defining them are in some algebraic extension of rationals. One cannot speak about real and p-adic fermions - just fermions.

Assumptions about the structure of conscious experience of self

One makes some structural assumptions about the contents of consciousness of self.

1. The contents of consciousness of self are determined as the average over the quantum jumps occurred after it was created (the real or p-adic space-time region corresponding to self appeared in quantum jump). Selves can have sub-selves and self experiences them as mental images. Self can represent a mental image of a higher level self. Self experiences only the average of its sub-sub-selves. Thus statistical averaging is involved in both subjecto-temporal sense and spatially and is of central importance in the theory of qualia. This suggests that the foundations of, not only quantum measurement theory, but also statistical physics, reduce to the theory of consciousness. Quantum entanglement between sub-selves means fusion of mental images. The simplest assumption is that entangling self loses its consciousness.
2. The sharing of mental images by quantum entanglement is purely TGD based prediction. What happens is rather paradoxical: the sub-selves of unentangled selves bound state entangle so that the resulting fused mental image is shared by both selves. This is not possible if one applies the standard notion of quantum mechanical sub-system as a tensor factor. The p-adic hierarchy of space-time sheets forces to generalize the notion of sub-system (note that also real space-time sheets are characterized by p-adic prime determining the size scale).

Smaller space-time sheets glued to larger space-time sheets are glued to it by wormhole contacts having size of order CP_2 length and having Euclidian signature of the induced metric. This implies the presence of elementary particle horizons at which metric around wormhole contacts changes its signature from Minkowskian to Euclidian. At these 3-dimensional surfaces the induced metric is degenerate so that these surfaces are effectively 2-dimensional and allow conformal invariance crucial for the construction of the quantum theory. The analogy with black hole horizon is obvious.

This allows a situation in which two systems correspond to disjoint surfaces but smaller space-time sheets glued to them are connected by magnetic flux tubes serving as correlates for entanglement. Therefore intuitively selves entangled in given length scale can have sub-selves, which are entangled.

3. Thus many-sheeted space-time and the notion of length scale resolution forces to postulate a hierarchy of systems labelled by p-adic primes and to allow entanglement between sub-systems of unentangled systems. In terms of length scale thinking of quantum field theories, one can say that the entanglement between sub-systems is not visible in the p-adic length and time scales of the systems themselves.

The mathematical description for this length scale dependent view about sub-systems relies on inclusions of hyper-finite factors of type II_1 (HFFs) [K141].

The notion of length scale resolution and self

The rough definition of self is as a subsystem able to remain unentangled during sequential quantum jumps. Self would lose consciousness when it entangles. What this statement really means is far from obvious and I have proposed several interpretations. the following picture represents the recent views.

1. The idea that even slightest entanglement leads to a loss of consciousness does not sound realistic. This suggests that entanglement should be defined only modulo finite measurement resolution. System would be conscious only provided that its entanglement entropy with the external world is below the value defined by the measurement resolution. For hyper-finite factors of type II_1 the notion of finite measurement resolution is unavoidable. The concrete interpretation at space-time level would be that space-time sheets (sub-selves) topologically condensed at larger space-time sheets (selves) can be connected by flux tubes to form an entangled state. The selves represented by the larger space-time sheets would remain unentangled in the resolution applying to the systems themselves (flux tubes would be invisible in this resolution). This invisible entanglement would however give rise to a sharing and fusion of mental images implying what might be called stereo consciousness.
2. How the notion measurement resolution should be defined is far from obvious. p-Adication approach suggests that finite measurement resolution boils down to a binary cutoff for the p-adic entanglement entropy represented as a series in powers of p . This binary cutoff should have also space-time correlate. For hyper-finite factors of type II_1 and type III_1 emerging naturally in quantum TGD entanglement entropy is always defined only modulo finite measurement resolution, which can be characterized in terms of inclusions of hyper-finite factors [K141]. The included factor defines the measurement resolution in the sense that its action creates states not distinguishable from the original in the resolution used. There should exist a connection between the two approaches.
3. A further complication is due to the fact that also the p-adic variants of Shannon entropy obtained by replacing the logarithm of probability with the logarithm of the p-adic norm of probability make sense if entanglement probabilities are rational or have values in some algebraic extension of rationals. The fact that number theoretic entanglement entropy can be negative is especially attractive from the point of view of consciousness theory and also quantum computation since entanglement indeed carries information. There is also a temptation to identify evolution as the emergence of increasingly complex systems having negative entanglement entropy. The generation of negative entanglement entropy might correspond to a kind of enlightenment experience - fusion to a sea of consciousness - instead of a loss of consciousness.
4. This forces to reconsider the original vision that everything is conscious but consciousness can be lost as the system entangles in U process. U process generates highly entangled states and the sub-sequent state function reduction (possibly modulo measurement resolution) repeatedly decomposes the Universe (or CD) into unentangled pairs of subsystems. The process stops for any subsystem for which all subsystem pairs have either bound state entanglement or negentropic entanglement (see **Fig.** <http://tgdtheory.fi/appfigures/cat.jpg> or **Fig. ??** in the appendix of this book). If the bound state entanglement is entropic, the entangled subsystems lose consciousness. If the entanglement between the subsystems is negentropic the process stops but subsystems remain conscious. Mystics might associate the entropic entanglement to what they call attachment and negentropic entanglement to a relationship which they might characterize as love.

NMP and self

NMP and self

The development of the view about Negentropy Maximization Principle (NMP) [K73] has meant also development of the notion of self.

- (a) The original formulation of NMP was in positive energy ontology and made same predictions as standard quantum measurement theory. The only new element was that the density matrix of sub-system defines a fundamental observable and the system goes to its eigenstate in state function reduction.
- (b) p-Adic physics led to the realization that for rational and even algebraic entanglement probabilities it is possible to define number theoretic entanglement negentropy satisfying the same basic axioms as the ordinary Shannon entropy but having negative values and therefore having interpretation as information. NMP would force the generation of negentropic entanglement and stabilize it. Negentropic entanglement resources of the Universe - one might call them Akashic records- would steadily increase.
- (c) It turned out that the consistency with the quantum measurement theory demands that the density matrix for the final state is projector as also in the standard quantum measurement theory but can project also to a higher-dimensional space. This additional condition allows also to identify negentropic entanglement uniquely: without this restriction one could not really say whether this is the case since rationals form dense set of reals.
- (d) The next step was to realize that this form of NMP is not realistic. NMP would force the Universe to be the best possible one, and this does not seem to be the case. Also ethically responsible free will would be very restricted since self would be forced always to do the best deed that is increase maximally the negentropy serving as information resources of the Universe. This led to the notion of weak form of NMP. Instead of maximal negentropy corresponding to n -dimensional projector self can choose also lower-dimensional sub-spaces and 1-D sub-space corresponds to the vanishing entanglement and negentropy assumed in standard quantum measurement theory.

Weak form of NMP suggests how to understand the notions of Good and Evil. Various choices in the state function reduction correspond to Boolean algebra, which suggests an interpretation in terms of what might be called emotional intelligence [K136]. Also it turns out that one can understand how p-adic length scale hypothesis - actually its generalization - emerges from NMOP [K140].

- (a) One can start from ordinary quantum entanglement. It corresponds to a superposition of pairs of states. Second state corresponds to the internal state of the self and second state to a state of external world or biological body of self. In negentropic quantum entanglement each is replaced with a pair of sub-spaces of state spaces of self and external world. The dimension of the sub-space depends on the which pair is in question. In state function reduction one of these pairs is selected and deed is done. How to make some of these deeds good and some bad?
- (b) Obviously the value of $h_{eff}/h = n$ gives the criterion in the case that weak form of NMP holds true. Recall that weak form of NMP allows only the possibility to generate negentropic entanglement but does not force it. NMP is like God allowing the possibility to do good but not forcing good deeds.

Self can choose any sub-space of the subspace defined by n -dimensional projector and 1-D subspace corresponds to the standard quantum measurement. For $n = 1$ the state function reduction leads to vanishing negentropy, and separation of self and the target of the action. Negentropy does not increase in this action and self is isolated from the target: kind of price for sin.

For the maximal dimension of this sub-space the negentropy gain is maximal. This deed would be good and by the proposed criterion the negentropic entanglement corresponds to love or more neutrally, positively colored conscious experience. Interestingly, there are $2^n - 1$ possible choices which is almost the dimension of Boolean algebra consisting of n independent bits. The excluded option corresponds to 0-dimensional sub-space - empty set in set theoretic realization of Boolean algebra. This could relate directly

to fermionic oscillator operators defining basis of Boolean algebra- here Fock vacuum would be the excluded state. The deed in this sense would be a choice of how loving the attention towards system of external world is.

- (c) A map between between the different choices of k -dimensional sub-space to k -fermion states is suggestive. The realization of logic in terms of emotions of different degrees of positivity would be mapped to many-fermion states - perhaps zero energy states with vanishing total fermion number. State function reductions to k -dimensional spaces would be mapped to k -fermion states: quantum jumps to quantum states!

The problem brings in mind quantum classical correspondence in quantum measurement theory. The direction of the pointer of the measurement apparatus (in very metaphorical sense) corresponds to the outcome of state function reduction, which is now 1-d subspace. For ordinary measurement the pointer has n positions. Now it must have $2^n - 1$ positions. To the discrete space of n pointer positions one must assign fermionic Clifford algebra of second quantized fermionic oscillator operators. The hierarchy of Planck constants and dark matter suggests the realization. Replace the pointer with its space-time n -sheeted covering and consider zero energy energy states made of pairs of k -fermion states at the sheets of the n -sheeted covering? Dark matter would be therefore necessary for cognition. The role of fermions would be to “mark” the k space-time sheets in the covering.

ZEO and self

Zero energy ontology brings in additional aspects to the notion of self. Zero energy states correspond to entangled pairs of positive and negative energy states located at the opposite light-like boundaries of a given causal diamond (CD) defined as the intersection of future and past directed light-cones. Strictly speaking a Cartesian product of CD with CP_2 is in question. CDs form a fractal hierarchy. In the ordinary ontology zero energy state corresponds to a physical event. The time-like entanglement between positive and negative energy states defines M -matrix generalizing the notion of S -matrix. Time-like entanglement must be fundamental also from the point of view of consciousness as a reduction of quantum state to a state with well defined values of observables for the initial (positive energy) and final (negative energy) states.

The most important input from ZEO is that state function reductions can occur to both boundaries of CD. The natural identification of self is as a sequence of state functions occurring at fixed boundary of CD leaving the state at it invariant but affecting the opposite position of opposite boundary. This if one has superposition of CDs with zero energy states associated with them and of unitary process generates quantum superposition of CDs in the moduli space of CDs and if the unitary process is followed by a localization in this moduli space. The first quantum jump to opposite boundary corresponds to a state function reduction in ordinary sense and has interpretation as volitional act. Self dies and reincarnates at the opposite boundary of CD.

In this picture one can assign to self a definite age as the increase of the proper time distance between the tips of CD. Also the experience of time flow can be understood. In each death of self a reversal of geometric time occurs. This conforms with the old proposal of Fantappie that the notion of syntropy makes sense in living systems [J92],

Space-time correlates of self

The identification of the space-time correlates of selves is not so obvious as one might think. One can imagine three options. The space-time correlates of selves are space-time sheets or CDs or somehow combinations of these two.

1. If space-time sheets serve as correlates for selves, the space-time correlate for the entanglement is the presence of magnetic flux tubes connecting the space-time sheets serving as correlates for selves. The entanglement which corresponds to join along boundaries bonds

associated with sub-selves (smaller space-time sheets topologically condensed at the space-time sheet representing self) is below the measurement resolution assignable to self. In this kind of situation selves remain conscious whereas sub-selves lose consciousness for positive entanglement entropy and fuse to form single stereo mental image of self. For negative entanglement entropy sub-selves would remain conscious.

2. In zero energy ontology [K31] one is forced to ask whether the correlates of self should be identified also at the level of embedding space rather than only at the level of space-time sheets so that a given CD would serve as a correlate for self. This identification leads to a beautiful argument for how the arrow of subjective time, the flow of subjective time, and the localization of the contents of conscious experience around a narrow time interval takes place [K10]. There is no reason for why *CDs* should not be allowed to overlap and this overlap would be a natural correlate for the sharing and fusion of mental images. Both of these identifications look natural and one can argue that the geometric correlates of self exist at both embedding space and space-time level.
3. If both space-time sheets and *CDs* serve as correlates for selves, the magnetic flux tube contacts could connect space-time sheets associated with the two. *CDs* would belong to their intersection. One can also require that the *CDs* are at the same p-adic level of hierarchy. In other words, *CDs* correspond to the same value of p-adic prime near a power of two meaning that the temporal distance between the tips of *CDs* is same octave of CP_2 time for the standard value of Planck constant. The hierarchy of Planck constants [K47] means an additional complication in this picture but does not bring in anything essentially new.

Since self behaves effectively like a separate autonomous universe, an attractive hypothesis is that the typical decomposition of self-organized system to almost autonomous subsystems corresponds to the decomposition of universe to selves. This means very close connection between self-organization theory and theory of consciousness.

Dark matter hierarchy and self

The notion of dark matter hierarchy has dramatically improve the understanding of the notion of self and together with NMP [K73] allows to even answer questions concerning Good and Evil and Life and Death [K136].

1. The idea about hierarchy of Planck constants emerged from anomalies of biology and the strange finding that planetary orbits could be regarded as Bohr orbits but with a gigantic value of Planck constant. This led to the vision that dark matter corresponds to ordinary particles but with non-standard value of Planck constant and to a generalization of the 8-D embedding space to a book like structure with pages partially characterized by the value of Planck constant. Using the intuition provided by the inclusions of HFFs one ends up to a prediction for the spectrum of Planck constants. This inspires the proposal that dark matter could be in quantum Hall like phase localized at light-like 3-surfaces with macroscopic size and behaving in many respects like black hole horizons.
2. The physical interpretation for the hierarchy of Planck constants would be in terms of a hierarchy of quantum criticalities concretizing the vision about quantum criticality of TGD Universe. TGD Universe would be like a hill at the top of a hill at The larger the Planck constant the larger the size scale of the hill. Criticality involves crucially the notion of conformal gauge symmetry. The conformal symmetries correspond to some sub-algebra of the full algebra isomorphic to it acting as gauge symmetries and with conformal weights coming as n -multiples of those for the full symmetry algebra. $h_{eff} = n \times h$ would label the levels of the hierarchy. This hierarchy would correspond directly to the hierarchy of measurement resolutions and to hierarchy of HFFs. Also now one obtains infinite hierarchies of symmetry breakings and the identification with the hierarchies of inclusions of HFFs is compelling. Hence various hierarchies reflect the same underlying phenomenon.
3. The phase transitions reducing criticality would take place spontaneously unlike opposite phase transitions. This vision is especially powerful in biology, where homeostasis could be

seen as mechanisms preventing the reduction of criticality but at expense of metabolic energy. The basic goal of living system would be staying at criticality. Eastern philosophies would formulate this fight for staying at criticality using the notions of ego and Karmic cycle. In the phase transition increasing $h_{eff} = n \times h$ part of gauge degrees of freedom assignable to a sub-algebra of the full super-symplectic algebra are transformed to physical ones and this implies better measurement resolution. The new HFF contains the previous one as a sub-factor. Evolution understood as increase of h_{eff} forced by Negentropy Maximization Principle as also interpretation improvement of measurement/cognitive resolution.

Dark matter hierarchy turns out to be crucial for the deeper understanding of the notion of self. In particular, the evolution of mental images as sequences of births and deaths of sub-selves correspond to state function reductions at opposite boundary of CD. These reductions are forced by NMP and can be said to occur spontaneously. The value of h_{eff} increases in these state function reductions while it remains constant during the sequence of state function reductions at fixed boundary defining self. Quantum criticality is reduced in these phase transitions and self has to fight to stay at fixed level of criticality. Self achieves this by the use of metabolic energy and homeostasis. As long self stays at criticality - that is alive- it's sub-selves can evolve by deaths and re-incarnations.

Dark matter hierarchy suggests also a slight modification of the notion of self. Each self involves a hierarchy of dark matter levels, and one is led to ask whether the highest level in this hierarchy corresponds to single quantum jump rather than a sequence of quantum jumps. The averaging of conscious experience over quantum jumps would occur only for sub-selves at lower levels of dark matter hierarchy and these mental images would be ordered, and single moment of consciousness would be experienced as a history of events. One can ask whether even entire life cycle could be regarded as a single quantum jump at the highest level so that consciousness would not be completely lost even during deep sleep. This would allow to understand why we seem to know directly that this biological body of mine existed yesterday.

The fact that we can remember phone numbers with 5 to 9 digits supports the view that self corresponds at the highest dark matter level to single moment of consciousness. Self would experience the average over the sequence of moments of consciousness associated with each sub-self but there would be no averaging over the separate mental images of this kind, be their parallel or serial. These mental images correspond to sub-selves having shorter wake-up periods than self and would be experienced as being time ordered. Hence the digits in the phone number are experienced as separate mental images and ordered with respect to experienced time.

2.2.4 General View About Psychological Time And Intentionality

A natural guess is that the resolution of the problems related to the preferred role of single moment of time for conscious experience could be based on the idea that biological growth and self-organization is a 4-dimensional phase transition proceeding in the direction of the geometric future quantum jump by quantum jump. And, in particular, that the dominating contribution to the conscious experience comes from the front of the phase transition where the volition is.

What is then this fundamental phase transition like phenomenon giving rise to what we call life? The front of phase transition could correspond to volitional consciousness. In Zero Energy Ontology (ZEO) volitional action begins with the first state function reduction to the opposite boundary of causal diamond (CD) involving "death" of corresponding self and re-incarnation at opposite boundary [?, K10]. Volition can be also seen as a transformation of intention to action. In the original vision this transformation was identified as p-adic-to-real phase transitions of space-time sheets taking place in quantum jumps. It has however turned out that this assumption creates more problems than it solves and that it is unnecessary if one accepts the adelic view meaning that the physics associated with all number fields form a coherent whole and p-adic physics is correlate for cognition. One can say that cognition is in the intersection of reality and various p-adicities defined by strong form of holography as string world sheets with the property that the parameters involved with their mathematical characterization are in algebraic extensions of rational numbers and can be thus algebraically continued to real and various p-adic number fields.

This view about time is the view of self about time as it shows itself as birth and death of mental images (sub-selves). The experienced continuous flow of time corresponds to a sequence

of state function reductions at a fixed boundary of CD not changing the state at this boundary [?, K10]. The sequences of these reductions defines self as conscious entity. Also the emergence of experienced time and its connection with the flow of geometric time can be understood in this framework. Thus the sequences of death/births of sub-selves define one time and second time corresponds to the continuous flow associated with state function reductions at the same boundary.

The phase transition like character of life has also more concrete interpretation. The hierarchy of Planck constants labelling phases of dark matter can be interpreted as a realization of quantum criticality of TGD Universe. The phase with a given value of $h_{eff} = n \times h$ corresponds to a phase in which super-symplectic conformal symmetry is broken in the sense that only the sub-algebra for which the conformal weights are n -ples for those of the entire algebra act as gauge symmetries. These phases are quantum critical and the phase transitions increasing n by integer multiple occur spontaneously. Living systems are fighting against this phase transition in all scales and try to stay at criticality with the help of metabolic energy and homeostasis. At the moment of death of self this phase transition is expected to occur. For sub-selves of self it occurs all the time as birth and death of mental images which evolve gradually.

Why sensory experience is about so short time interval?

The picture based on CDs implies automatically the 4-D character of conscious experience and memories form part of conscious experience even at elementary particle level. Amazingly, the secondary p-adic time scale of electron is $T = 0.1$ seconds defining a fundamental time scale in living matter. The problem is to understand why the sensory experience is about a short time interval of geometric time rather than about the entire personal CD with temporal size of order life-time. The explanation would be that sensory input corresponds to sub-selves (mental images) with $T \simeq .1$ s at the upper light-like boundary of CD in question. This requires a strong asymmetry between upper and lower light-like boundaries of CDs.

The localization of the contents of the sensory experience to the upper light-cone boundary and local arrow of time could emerge as a consequence of self-organization process involving conscious intentional action. Sub-CDs would be in the interior of CD and self-organization process would lead to a distribution of CDs concentrated near the upper or lower boundary of CD. The local arrow of geometric time would depend on CD and even differ for CD and sub-CDs.

1. The localization of contents of sensory experience to a narrow time interval would be due to the concentration of sub-CDs representing mental images near the either boundary of CD representing self.
2. Phase conjugate signals identifiable as negative energy signals to geometric past are important when the arrow of time differs from the standard one in some time scale. If the arrow of time establishes itself as a phase transition, this kind of situations are rare. Negative energy signals as a basic mechanism of intentional action and transfer of metabolic energy would explain why living matter is so special.
3. Geometric memories would correspond to sub-selves in the interior of CD, the oldest of them to the regions near “lower” boundaries of CD. Since the density of sub-CDs is small there geometric memories would be rare and not sharp. A temporal sequence of mental images, say the sequence of digits of a phone number, would correspond to a temporal sequence of sub-CDs.
4. Sharing of mental images corresponds to a fusion of sub-selves/mental images to single sub-self by quantum entanglement: the space-time correlate could be flux tubes connecting space-time sheets associated with sub-selves represented also by space-time sheets inside their CDs.

Arrow of time

TGD forces a new view about the relationship between experienced and geometric time. Although the basic paradox of quantum measurement theory disappears the question about the arrow of geometric time remains. There are actually two times involved. The geometric time assignable to the space-time sheets and the M^4 time assignable to the embedding space.

The emergence of the arrow of time at the level of embedding space reduces to a modification of the oldest TGD based argument for the arrow of time which is wrong as such. If physical objects correspond to 3-surfaces inside future directed light-cone then the sequence of quantum jumps implies a diffusion to the direction of increasing value of light-cone proper time. The modification of the argument goes as follows.

1. CDs are characterized by their moduli. In particular, the relative coordinate for the tips of CD has values in past light cone M_-^4 if the future tip is taken as the reference point. An attractive interpretation for the proper time of M_-^4 is as cosmic time having quantized values. Quantum states correspond to wave functions in the modular degrees of freedom and each U process creates a non-localized wave function of this kind. Suppose that state function reduction implies a localization in the modular degrees of freedom so that CD is fixed completely apart from its center of mass position to which zero four-momentum constant plane wave is assigned. One can expect that in average sense diffusion occurs in M_-^4 so that the size of CD tends to increase and that the most distant geometric past defined by the past boundary of CD recedes. This is nothing but cosmic expansion. This provides a formulation for the flow of time in terms of a cosmic redshift. This argument applies also to the positions of the sub-CDs inside CD. Also their proper time distance from the tip of CD is expected to increase.
2. One can argue that one ends up with contradiction by changing the roles of upper and lower tips. In the case of CD itself is only the proper time distance between the tips which increases and speaking about “future” and “past” tips is only a convention. For sub-CDs of CD the argument would imply that the sub-CDs drifting from the opposite tips tend to concentrate in the middle region of CD unless either tip is in a preferred position. This requires a spontaneous selection of the arrow of time. One could say that the cosmic expansion implied by the drift in M_-^4 “draws” the space-time sheet with it to the geometric past. The spontaneous generation of the asymmetry between the tips might require the “curious” conscious entities.

2.2.5 Two Views About Flow Of Time

One can consider two alternative views about how the subjectively experienced flow of time emerges.

1. The first view would identify the flow of time with life cycle of period and essentially with sensory perception defining the passive aspects of consciousness. This view is consistent with the ZEO based about self and looks rather feasible. One can wonder how repeated state function reduction give rise to the increase of the average size of CD (possibly in superposition of CDs). Why the entire zero energy state and CD do not remain unchanged in state function reduction? What is the unitary process defining the dynamics of dispersion in the moduli space of CDs? One must admit that this aspect is not well-understood yet and more detailed view about what the sequences of state function reductions really means.
2. Second view that I have considered assigns the flow of time with active aspects of consciousness.
 - (a) The acts of volition would give rise to an experience about flow of time. The proposal is that in ZEO act of volition corresponds to the first state function reduction at the opposite boundary of some sub-CD. Some self in the hierarchy dies in this process and NMP forces it to occur although it does not fix the outcome.

Time mirror mechanism for motor action assumes that the phase transition gives rise to negative energy space-time sheets representing propagation of signals to geometric past, where they induce neuronal activities. From Libet’s experiments relating to neuronal correlates of volition the time scale involved is a fraction of second but an infinite hierarchy of time scales is implied by fractality. Perhaps the most logical interpretation is that state function reduction sequences with opposite arrows of time correspond to sensory perception and motor action from the point of view of a higher level self with larger CD.

- (b) Skeptic can argue that the act of volition in this sense is only a choice between alternative outcomes of state function reduction rather than a realization of intention as action creating something genuinely new: a new real space-time sheet from p-adic space-time sheet. One can however argue that genuine volitional acts are realizations of intentions. The reason is that NMP defines the goal of the dynamics and means that total quantum randomness does not prevail anymore.

One can also argue that there is no actual choices between good and evil. This is certainly not the case if weak form of NMP which only allows the reduction to any subspace of the subspace with the dimension of the projection operator appearing in density matrix.

These view can be understood as mutually consistent ways to understand the flow of time. The first flow would be pseudo-continuous and correspond to translation in time and second one would occur in discontinuous steps and correspond a scaling of CD. These time developments corresponds to time evolutions in ordinary QFT and in conformal field theory respectively.

Consider first how the smooth flow of subjective time during the life cycle of self emerges.

1. One can argue that the value of h_{eff} associated with a given self cannot increase during the lifetime of self since this would scale up also the size of the passive boundary of CD and thus also the sizes of 3-surfaces there. The explanation for the flow of geometric time however demands that the size of CDs in the superposition increases.

This requires a linear increase in which CD size increases by integer rather than being scaled by integer: shift instead of scaling. This criterion would suggests that the increase of the size of CD is below scaling by factor two - below a more flexible option is considered - and relate the lifetime of self to the size scale of CD.

2. The basic mathematical challenge is to formulate the transition amplitudes between different CDs. Is the transition amplitude essentially an overlap of fermionic lines associated with the two CDs? In Yangian approach the transition amplitude would reduce to an overlap integral associated with the string world sheets belonging to both CDs. This would favor the increase of the size of CD. It is not clear whether it makes sense to assume a localization to single CD to take place at every step localizing only its active boundary. Certainly state function reduction in the degrees of freedom associated with this boundary of CD cannot occur since this would reverse the direction of time.

The time evolution during the single step keeping passive boundary of CD corresponds to a shift for the integer specifying the size scale of CD. Can one interpret this shift as a fractional scaling $n \rightarrow n(1 + \Delta n/n)$ or does this shift correspond to translation by representable in terms of Poincare energy as Noether charge? The latter option looks more natural. This time evolution would be the one usually studied in quantum field theories.

3. Interesting questions relate to the constraints coming from number theoretical universality forced by adelization. Could the increase of h_{eff} correspond to the increase of p-adic prime characterizing the system? What about p-adic counterpart of unitary evolution: the existence of the exponential $\exp(iP_0 t)$ requires that t has p-adic norm below some upper bound. This could give an upper bound to the life time of self as a real number since the p-adic counterpart of life-time would be below this upper bound.

What happens in the first reduction to the opposite boundary of CD changing the arrow of time?

1. The reduction should be forced by NMP and involve scaling of h_{eff} generating negentropic entanglement. Thus the scaling of h_{eff} and reduction of quantum criticality would be possible only in the first reduction to the opposite boundary - biological death. Life cycle would end when the transition increasing h_{eff} would occur and at least tend increase negentropic entanglement. The tendency of living system to stay at criticality using metabolism and homeostasis would translate to the urge to maximize the life span, which looks indeed natural.

2. At the level of sub-selves this scalings can occur for self and would correspond to mental images with are born and die. Also motor action would correspond to a transition changing the arrow of time for a mental image representing the intention and will to perform the motor action.
3. One can argue that the increase of h_{eff} giving also rise to an increase in negentropy becomes unavoidable eventually. This criticality could mean that the size scale of CD becomes integer multiple of the original one.

For instance, when the size scale of personal CD approaches to a value which is twice that of the original one, the situation is expected become highly critical for $h_{eff} \rightarrow 2 \times h_{eff}$ transition. Could it be possible to avoid this phase transition so that the biological death could correspond to $h_{eff} \rightarrow n \times h_{eff}$, $n > 2$? The manner to avoid the phase transition would be by the generation of negentropic entanglement at the level of mental images and by the corresponding phase transitions for them - can one see spiritual thoughts as a way to live longer?

4. In the first reduction to the opposite boundary the negentropy increases and also the value of h_{eff} presumably does (by NMP). Does this mean that self can gain wisdom only by dying! The intuitive idea is that ageing is accompanied by increase of wisdom of some kind. But *if* one assigns negentropic entanglement with the passive boundary, negentropy associated with the length scale of CD remains unchanged.

There is however a loophole. For the sub-selves associated with sub-CDs the situation is different. Given mental image of self/sub-self can live several life-cycles meaning that it generates (or can generate) negentropic entanglement. Mental images of self get wiser even if self does not! The refusal of self to grow spiritually would make possible for sub-selves to grow spiritually: one cannot cheat NMP!

5. The scaling of CD inducing the increase of $h_{eff} = n \times h$ occurring spontaneously represented as an exponential of scaling generator - call it L_0 - seems to be precede the first reduction. I have already considered conditions on this dynamics. Note that translations are replaced with scalings by integer valued ratios $m = n_f/n_i$, which predicts that periodicity is replaced by periodicity with respect to the logarithm of ordinary embedding space time. A unique signature of dynamics of consciousness, which I have proposed as an explanation for the hyperbolic decay law for the emission of bio-photons.
6. The scaling of CD inducing the increase of $h_{eff} = n \times h$ occurring spontaneously is naturally represented as an exponential of scaling generator - call it L_0 . Translations are replaced with scalings by integer valued ratios $m = n_f/n_i$, which predicts that periodicity is replaced by periodicity with respect to the logarithm of ordinary embedding space time. A unique signature of dynamics of consciousness, which I have proposed as an explanation for the hyperbolic decay law for the emission of bio-photons.
7. The phase transitions increasing $h_{eff}/h = n$ can be said to begin from some prime value $n = p$ - the smallest prime power appearing in n : one could even say that the basic label for the sequences of breakings of super-symplectic symmetries are labelled by primes. This strongly suggests a connection with p-adicity.

These two views are consistent with each other. The first view corresponds to a flow of time as shifts in the integer characterizing the size of CD and corresponds to the flow of time experienced by self during its life-cycle. The second view corresponds to time evolution as a sequence of state function reductions at opposite boundary involving scalings of h_{eff} by integer. The tick for this clock would be a phase transition reducing quantum criticality. Self experiences this time flow as sequence of mental images which live and die.

2.3 Macro-Temporal Quantum Coherence And Spin Glass Degeneracy

At the space-time level the generation of macroscopic quantum coherence is easy to understand if one accepts the identification of the space-time sheets as coherence regions. Quantum criticality and the closely related spin glass degeneracy are essential for the fractal hierarchy of space-time sheets. The problem of understanding macro-temporal and macroscopic quantum coherence at the level of WCW is a more tricky challenge although quantum-classical correspondence strongly suggests that this is possible. In the sequel the notion of macro-temporal quantum coherence is discussed in quantum TGD framework and the argument for how quantum spin glass degeneracy implies macro-temporal quantum coherence is developed.

2.3.1 What Does Quantum Coherence Mean In TGD Universe?

Concerning macro-temporal quantum coherence, the situation in quantum TGD seems at the first glance to be even worse than in standard physics. The problem is that simplest estimate for the increment in psychological time in single quantum jump is about 10^{-39} seconds derived from the idea that single quantum jump represent a kind of elementary particle of consciousness and thus corresponds to CP_2 time of about 10^{-39} seconds. If this time interval defines coherence time one ends up to a definite contradiction with the standard physics. Of course, the average increment of the geometric time during single quantum jump could vary and correspond to the de-coherence time. The idea of quantum jump as an elementary particle of consciousness does not support this assumption.

To understand how this naïve conclusion is wrong, one must look more precisely the anatomy of quantum jump. The unitary process $\Psi_i \rightarrow U\Psi_i$, where Ψ_i is a prepared maximally unentangled state, corresponds to the quantum computation producing maximally entangled multi-verse state. Then follows the state function reduction and after this the state preparation involving a sequence of self measurements and given rise to a new maximally unentangled state Ψ_f .

1. What happens in the state function reduction is a localization in zero modes, which do not contribute to the line element of the WCW metric. They are non-quantum fluctuating degrees of freedom and TGD counterparts of the macroscopic, classical degrees of freedom. There are however also quantum-fluctuating degrees of freedom and the assumption that zero modes and quantum fluctuating degrees of freedom are correlated like the direction of a pointer of a measurement apparatus and quantum numbers of the quantum system, implies standard quantum measurement theory.
2. Bound state entanglement is assumed to be stable against state function reduction and preparation. Bound state formation has as a geometric correlate formation of flux tubes between space-time sheets representing free systems. Thus the members of a pair of disjoint space-time sheets are joined to single space-time sheet. Half of the zero modes is transformed to quantum fluctuating degrees of freedom and only overall center of mass zero modes remain zero modes. These new quantum fluctuating degrees of freedom represent macroscopic quantum fluctuating degrees of freedom. In these degrees of freedom localization does not occur since bound states are in question.

Both state function reduction and state preparation stages leave this bound state entanglement intact, and in these degrees of freedom the system behaves effectively as a quantum coherent system. One can say that a sequence of quantum jumps binds to form a single long-lasting quantum jump effectively. This is in complete accordance with the fractality of consciousness. Quantum jumps represent moments of consciousness which are elementary particles of consciousness and in macro-temporal quantum coherent state these elementary particles bind to form atoms, molecules, etc. of consciousness.

3. The properties of the bound state plus its interaction with the environment allow to estimate the typical duration of the bound state. This time takes the role of coherence time. This suggests a connection with the standard approach to quantum computation.

2.3.2 Many-Sheeted Space-Time, Topological Field Quantization, And Spin Glass Degeneracy

Many-sheeted space-time allows to understand topologically the generation of structures. Even the macroscopic objects of every-day world correspond to space-time sheets. The replacement of point-like particles with 3-surfaces of arbitrarily large implies the crucial non-locality at space-time level. Concerning the understanding of bio-super-conductivity, the basic observation is that the space-time sheets, which are much larger than atomic space-time sheets, contain very low densities of ordinary particles so that the temperature can be extremely low and macroscopic quantum phases are possible.

Topological field quantization, which is implied both by topological reasons and by the fact that only the extremals of Kähler action allowing infinite number of deformations with a vanishing second variation, implies that space-time surfaces are counterparts of Bohr orbits and have complex topology. This means that topologically relatively featureless linear Maxwell fields are replaced by extremely complex topological structure, which can be regarded as kind of a generalized Feynman diagram obtained by thickening the lines to four-dimensional space-time sheets.

Quantum-classical correspondence has been a basic guideline in the construction of the theory and states that classical space-time physics provides classical correlates for various quantum aspects of physical system leads to the view that the topological field quanta accompanying a given material system provide a representation for its quantum structure, kind of a manual.

The topological self-referentiality generalizes further to the idea that the inherent non-determinism of the p-adic dynamics makes possible space-time representation of quantum jump sequences and classical non-determinism of Kähler action the non-determinism inherent to the linguistic representations for the contents of consciousness of self. This in turn implies feedback loop to WCW (of 3-surfaces) level: WCW spinor fields can represent (not faithfully) quantum jump sequences and thus the contents of consciousness associated with a sequence of quantum jumps (self), so that the ability to become conscious about being conscious about something can be understood.

One can also speak about “field body” (or actually hierarchy of them) as being associated with the material system. This field body, which is much larger than the material system, serves as a sensory canvas at which sensory representations are realized and could also perform motor control. This means radical modification of the neuro-science view about brain as the sole seat of consciousness [K67, K65].

The basic variational principle underlying quantum TGD states that the space-time surface associated with a given 3-surface is preferred extremal of so called Kähler action, which is essentially Maxwell action for a Maxwell field, which is obtained by projecting CP_2 Kähler form to space-time surface. Thus primary dynamical variables are CP_2 coordinates rather than vector potential. This implies huge vacuum degeneracy: any space-time surface having CP_2 projection, which is Legendre manifold, that is at most a 2-dimensional surface of CP_2 having vanishing induced Kähler form, is a vacuum extremal. New vacua are obtained by the canonical transformations of CP_2 acting as $U(1)$ gauge transformations on Kähler gauge potential. This symmetry is also approximate for non-vacuum extremals and broken only by classical gravitation represented by the induced metric.

Physically this means spin glass degeneracy: the geometric $U(1)$ gauge invariance ceases to be gauge invariance (nothing to do with ordinary gauge invariance) and implies huge almost-degeneracy of physical states. Gravitational energy distinguishes between these almost physically equivalent states. The standard manner to visualize the situation is by using the notion of the energy landscape. Spin glass energy landscape (now energy corresponds to Kähler function) is a fractal structure containing valleys inside valleys inside... This symmetry is responsible for a very large class of phenomena distinguishing between TGD and standard physics and also makes possible macro-temporal quantum coherence.

2.3.3 Spin Glass Degeneracy And Classical Gravitation As Stabilizer Of Irreducible Bound State Entanglement

This picture gives connection with the standard physics view but does not yet explain why decoherence times are so long. New physics is required to explain why the life times of quantum states are much longer than predicted by the standard physics. Spin glass degeneracy provides

this physics. There are two arguments: probabilistic argument based on intuition and the more rigorous argument based on unitarity.

Probabilistic argument

The probabilistic argument goes as follows.

1. Suppose that spin glass degeneracy gives rise to a huge number of almost degenerate bound states for which only the classical gravitational energy is different, and that for non-bound states this degeneracy is much smaller. The dominant part of the binding energy is of course something else than gravitational. If this is the case, the number of the bound states is so large as compared to the number of unbound states that the branching ratio for the decay to unbound state is very small. This means that the time spent in bound states is much longer than the time spend in free states and this means that de-coherence time is much longer than without spin glass degeneracy.
2. If the flux tubes are sufficiently near to vacuum extremals, they indeed allow immense spin glass degeneracy with slightly different gravitational interaction energies and the desired situation can be achieved.

The argument based on unitarity

A more refined argument is based on unitarity of S-matrix. The S-matrix can be written as sum of unit matrix and reaction matrix T : $S = 1 + iT$.

1. The unitarity conditions $SS^\dagger = 1$ read in terms of T-matrix as

$$i(T - T^\dagger) = TT^\dagger . \quad (2.3.1)$$

For diagonal elements one has

$$2 \times \text{Im}(T_{mm}) = \sum_r |T_{mr}|^2 \geq 0 . \quad (2.3.2)$$

What is essential that the right hand side is non-negative and closely related to the total rate of transitions. If this rate is high also the imaginary part at the left hand side of the equation is large and therefore also the rate for the diagonal transition. For instance, in the case of low energy strong interactions this implies that the total reaction rates are high but transitions occur mostly in the forward direction. In this case the mere large number of final many-hadron states implies that most transitions occur in the forward direction.

In the recent case one must consider both free states and bound states. Let us use capitals M, N as labels for bound states and small letters m, n as labels for free states.

2. The diagonal unitarity conditions can be written for both of these states as

$$\begin{aligned} 2\text{Im}(T_{mm}) &= \sum_r |T_{mr}|^2 + \sum_R |T_{mR}|^2 \geq 0 , \\ 2\text{Im}(T_{MM}) &= \sum_R |T_{MR}|^2 + \sum_r |T_{Mr}|^2 \geq 0 . \end{aligned} \quad (2.3.3)$$

In both cases there is a large number of the degenerate states involved at the right hand side so that one expects that the right hand side has a large value. For bound states the number of degenerate states is much higher due to the additional degeneracy brought in by the flux tubes. Thus the lifetime and de-coherence time should be considerably longer than expected on basis of standard physics.

3. For the non-diagonal transitions from bound states to free states one has

$$i(T_{Mm} - \bar{T}_{mM}) = \sum_r T_{Mr} \bar{T}_{mr} + \sum_R T_{MR} \bar{T}_{mR} . \quad (2.3.4)$$

The right hand side is not positive definite and since a large number of amplitudes between widely different free and bound states are involved, one expects that a destructive interference occurs. This is consistent with a small value of the non-diagonal amplitudes T_{Mm} and with the long lifetime of bound states.

4. What happens for non-diagonal transitions between degenerate states? The unitarity conditions read as

$$\begin{aligned} i(T_{mn} - \bar{T}_{nm}) &= \sum_r T_{mr} \bar{T}_{nr} + \sum_r T_{mR} \bar{T}_{nR} , \\ i(T_{MN} - \bar{T}_{NM}) &= \sum_R T_{MR} \bar{T}_{NR} + \sum_r T_{Mr} \bar{T}_{Nr} . \end{aligned} \quad (2.3.5)$$

The right hand side is not anymore positive definite and there is a very large number of summands present. Hence a destructive interference could occur and the amplitude would be very strongly restricted in the forward direction. This need not however be true in the case of degenerate states since they are expected to be very similar to each other.

5. One can indeed play with the idealization that the transition amplitudes between degenerate states are identical $T_{MN} = T$ and that the amplitudes T_{Mr} are independent of M and given by $T_{Mr} = T_r$.

In this case T-matrix would have the form $T = t \times X$, where X is a matrix for which all elements are equal to one. t can be written as $|t| \exp(i\phi)$. T -matrix is maximally degenerate and the diagonalized form T^D of T-matrix has only a single non-vanishing element equal to Nt , N the number of degenerate states. t must satisfy the unitarity condition $|t| = 2 \times \sin(\phi)/N$. S-matrix would reduce to an almost unit matrix for the diagonalized bound states.

What about the stability of the bound states in this case? The decay amplitudes for bound states corresponding to the vanishing eigen values of T are given by $T^D(M, r) = \sum c_M T_{Mr} = \sum_M c_M \times T_r = 0$ by the orthogonality of these states with the state with a non-vanishing eigen value. Thus the lifetimes of all bound states except the one with the non-vanishing eigen value of T are infinitely long in this idealization.

Color confinement and spin glass degeneracy

This mechanism has applications also outside consciousness theory. For instance, one can understand color confinement. When quarks form color bound states, their space-time sheets are connected by color flux tubes (this is the aspect of confinement which goes outside QCD). Also color flux tubes possess huge spin glass degeneracy. Free quark states do not possess this degeneracy since flux tubes are absent. Thus the time spent in free states in which color flux tubes are absent is negligible compared with the time spent in color bound states so that the states consisting of free quarks are unobservable.

A more precise phrasing of this idea relies on unitarity conditions and the assumptions $T_{MN} \simeq T$ and $T_{Mr} \simeq T_r$. Here capital subscripts refer to degenerate hadronic states and small letter subscripts to free many-quark states. In this idealization hadronic degenerate states are stable against decay to free many-quark states with only single exception. The exceptional state should act as a doorway making possible the transition to quark-gluon plasma phase.

S-matrices associated with a hierarchy of de-coherence times

The Hamiltonian time evolution would more or less correspond to a unitary operator resulting as a product of the actions of the unitary operators U associated with the quantum jumps of the sequence. The interpretation is as a length/time scale dependent time development operator obtained by integrating over the spin glass degrees of freedom. This is natural since spin glass degrees of freedom represent hidden variables and degenerate bound states correspond to one and the same bound state in the standard physics view about Universe. Discretized time development emerges automatically in this framework. The Schrödinger equation at the infinitesimal level does not make sense but this is of course not a practical problem. One could say that the sequence of quantum jumps defining the conscious experience of self is able to simulate the unitary time evolution associated with single quantum history.

One might argue that this kind of description is unsatisfactory since unitarity might be only approximate. The fractality of consciousness however suggests that the unitary might be exact. First of all, the standard definition of sub-system must be replaced with a length scale dependent one involving length scale cutoff (sharing of mental images is one important implication). This is expected to be true also in the temporal domain so that also S-matrices form a hierarchy characterized by the durations of macro-temporal quantum coherence. The spatial and temporal resolutions would not be due to the limitations of the theorist or of the experimenter but basic properties of the subjective, physical, and mathematical existences, and p-adic length scale hierarchy would provide the natural hierarchy of resolutions. The finite geometro- and subjecto-temporal resolutions might make possible exact unitarity for the S-matrices appearing in this hierarchy.

S-matrix would be replaced by a collection of S-matrices. At space-time level this presumably means the possibility and necessity to assign S-matrices to space-time sheet defining coherence regions. De-coherence, which would involve the decay of the space-time sheet to smaller space-time sheets representing outgoing particles and the generation of coherence as a time reversal of this process involving incoming particles would be an essential part of the construction of S-matrix. The relationship between hadronic physic and quark physics brings strongly in mind this situation.

2.4 Macro-Temporal Quantum Coherence, Spin Glass Degeneracy, And Hierarchy Of Planck Constants

The original vision was that spin glass degeneracy is behind macroscopic quantum coherence. A more concrete vision emerged around 2005 when it was realized that ordinary quantum theory as such is probably not enough to understand macroscopic quantum coherence. In the following I summarize the original ideas and then summarize the later development of the ideas about hierarchy of Planck constants.

2.4.1 Many-Sheeted Space-Time, Topological Field Quantization, And Spin Glass Degeneracy

Many-sheeted space-time allows to understand topologically the generation of structures. Even the macroscopic objects of every-day world correspond to space-time sheets. The replacement of point-like particles with 3-surfaces of arbitrarily large implies the crucial non-locality at space-time level. Concerning the understanding of bio-super-conductivity, the basic observation is that the space-time sheets, which are much larger than atomic space-time sheets, contain very low densities of ordinary particles so that the temperature can be extremely low and macroscopic quantum phases are possible.

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aspects of physical system leads to the view that the topological field quanta accompanying a given material system provide a representation for its quantum structure, kind of a manual.

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2.4.2 The Evolution Of Ideas About Hierarchy Of Planck Constants

The evolution of ideas about about Planck constant began around 2005. The following brief summary represents the original ideas and short summary about their later evolution to the recent (2015) vision. Contrary to the original expectation TGD in its original form can accommodate the idea and one could also say that the spectrum of Planck constants is only effective.

Quantization of planetary orbits with a gigantic value of Planck constant and dark matter as a macroscopic quantum phase

There is evidence that planetary orbits obey Bohr quantization rules with a gigantic value of Planck constant [E2]. Nottale does not assume that this quantization is genuine but regards it as a hydrodynamical effect. In TGD framework the most natural interpretation is in terms of dynamical Planck constant and TGD even predicts correctly the basic dimensionless parameter involved [K111, K141, K43].

The notion of a macroscopic Bohr orbit is not a problem in TGD framework since the basic variational principles implies that space-time surfaces can be regarded as generalized Bohr orbits. The assignment of a Schrödinger amplitude to ordinary matter in astrophysical length and time scales is of course non-sensible in standard physics approach. The resolution of the paradox comes from the identification of dark matter in terms of a hierarchy of macroscopically quantum coherent large \hbar phases around which visible matter condenses. There is no direct interaction between phases of matter with different values of \hbar since all particles in fundamental vertices have same value of \hbar . De-coherence phase transition reducing the value of \hbar and the reverse of this phase transition are possible. At classical level intricate interaction mechanisms are possible due to the

properties of the many-sheeted space-time. For instance, this kind of mechanism plays key role in the model of nerve pulse generation [K96].

One ends up also to a criterion for the occurrence of the phase transition increasing the value of the Planck constant. The idea is that when perturbation theory in powers of the gauge coupling constants fails, a phase transition increasing the value of \hbar occurs so that coupling constant strength which is proportional to $1/\hbar$ is reduced and the resulting perturbation theory converges rapidly. Somewhat paradoxically, the large value of Planck constant implying formation of macroscopic quantum phases means also that the resulting system behaves more classically in the sense that higher order contributions in perturbation theory become small.

This picture leads to a rather precise vision about what happens in color confinement (valence quarks correspond to large value of \hbar). The implications are highly nontrivial also at the level of nuclear physics and lead to an identification of nuclei as highly folded stringlike structures. The model also forces to give up the assumption that nuclear physics and condensed matter physics have nothing to do with each other.

The large values of \hbar mean macroscopic and macrotemporal quantum coherence. Various quantum scales such as Compton time and length are proportional to \hbar and are scaled up by n in the phase transitions increasing \hbar . Also de-coherence times and lengths are scaled up. These scales correspond at the space-time level the scales of the space-time sheets involved. Thus a phase transition increasing n but not affecting particle densities can lead to a situation in which the space-time sheets associated with particles zoomed up by n overlap so that the criterion for macroscopic quantum coherence is satisfied.

Summary about the evolution of ideas about hierarchy of Planck constants

The following summarizes the recent bird's eye of view about the evolution of the ideas about the hierarchy of Planck constants.

1. The hierarchy of Planck constants labelling levels of dark matter hierarchy was the proposed generalization. Planck constant is usually regarded as a universal constant which can be taken to be $\hbar = 1$ if units are chosen suitably. For some reason that possibility that Planck constant might be dynamical has not been considered as a possible option by quantum consciousness theorists. My own views changed profoundly as I learned about the work of Laurent Nottale [E2] introducing the notion of gravitational Planck constants but in classical context. My own proposal was that astro-scopic quantum coherence could be something very real. The vision was that when the coupling parameter (now gravitational coupling strength GMm/h) becomes strong, a transition to dark phase with h replaced with h_{eff} occurs: Nature takes in this manner care that the situation remains perturbative. In the case of gravitation this gives $h_{eff} = h_{gr} = GMm/v_0$, v_0 a parameter with dimensions of velocity.
2. Second stimulus came from the quantal looking effects of ELF radiation on vertebrate brain [J31] at frequencies which correspond to cyclotron frequencies for Ca^{++} ion in magnetic field which is about $2/5$ fraction of nominal value .5 Gauss of the magnetic field of Earth. Large value of $h_{eff} = n \times h$ (this hypothesis emerged later) would raise the cyclotron energies proportional to h_{eff} above thermal energy. Years later $h_{eff} = h_{gr}$ idea was revived [K88] and led to a model of bio-photons identified as dark cyclotron photons transformed to ordinary photons with the same energy and satisfying $h_{eff} = h_{gr}$ implying that the energy spectrum does not depend on the mass of the charged particle so that biophoton energy spectrum is universal and in visible and UV range characterizing bio-molecules and reflecting the spectrum of magnetic field strengths.
3. The original proposal was that the hierarchy of Planck constants accompanies a hierarchy of singular n -sheeted coverings of embedding space assignable to CDs. Later it became clear the non-determinism of Kähler action suggests the existence of space-time surfaces, which are singular n -sheeted coverings with sheets collapsing to single 3-surface at the boundaries of CD (n -braches at both ends of space-time). An important step in the progress was the interpretation in terms of hierarchy of quantum criticalities [K36, K37, K38, K39]. One cannot exclude even the possibility that also thermodynamical criticality involves large values of Planck constant. A good example is provided by the fountain effect of super-fluidity, where

macroscopic quantum gravitation might become manifest. Hierarchy of Planck constants labels these phases and sub-algebra of super-symplectic algebra with conformal weights n -ples of those for the full algebra acts as a gauge algebra. TGD Universe is like ball at the top of hill at the top of hill at...

The phase transitions increasing h_{eff} appear spontaneously in the first state function reductions to the opposite boundary of CD meaning death of self. Living systems are doing their best to stay at criticality and metabolism and homeostasis help to achieve this goal.

4. One of the dramatic predictions is that the formation of gravitationally bound states is not possible in TGD Universe - and maybe also in that predicted also by string models - if fermionic strings connecting partonic 2-surfaces serve as correlates for their formation and implying macroscopic quantum gravitational coherence. In string models it is impossible to say anything about the situation since long length scale limit is just an ad hoc assumption rather than something following from the basic theory. The most natural guess is that the only bound states have size scale of order Planck length in string models.
5. The most recent discovery is that the hierarchy of Planck constants relates closely to the number theoretical hierarchy of algebraic extension of rational numbers at the core of adelic TGD. String world sheets and partonic 2-surfaces characterized by parameters in algebraic extensions of rationals define the genes of space-time. They must allow continuation to space-time surfaces in various number fields. For real space-time surfaces this need not always be possible whereas p -adic pseudo constants make the continuation easy in various p -adic cases. The 2-surfaces not continuable to real space-time surface would be correlates for pure imagination: imaginable but not realizable.

4-D spin glass degeneracy is the prerequisite for the hierarchy of Planck constants. The hierarchy of n -sheeted singular coverings reflects the non-determinism accompanying the degeneracy (and criticality in general) and the proposal is that there is genuine gauge degeneracy in the sense that each space-time sheet is replaced by conformal gauge equivalence class. For light-like 3-surfaces, which would correspond to transforms of the 3-surface keeping it light-like and singular in the sense that the metric of induced metric vanishes at the surface because it serves as boundary of regions with Minkowskian and Euclidian signatures of the induced metric. This gauge invariance can be realized by demanding that classical Noether charges associated with the sub-algebra of super-symplectic algebra characterized by n vanish at the ends of space-time. This realizes also strong form of holography.

2.5 Basic Implications

In the sequel the physical aspects of the macro-temporal quantum coherence are discussed.

2.5.1 Information Theoretic Aspects

TGD framework forces to reconsider also the notion of information itself, and the new number-theoretic view about information suggests a profoundly new view about the distinction between dead and living matter and about about consciousness as the basic driving forces behind evolution. At practical level this might have radical implications for quantum computation [K3]. These aspects are discussed in detail in [K73, K101] and in the following only the main points are discussed. What is important that weak form of NMP [K73], which is information theoretic variational principles, allows together with ZEO to deduce the basic predictions of TGD inspired theory of consciousness and quantum biology. In this picture the hierarchy of Planck constants (quantum criticalities), p -adic physics, the notion of negentropic entanglement are very tightly interwoven.

Number theoretic information measures

The notion of information in TGD framework differs in some respects from the standard notion.

1. The definition of the entropy in p -adic context is based on the notion p -adic logarithm depending on the p -adic norm of the argument x only ($x = p^n r/s$, r and s not divisible

by p ; $\text{Log}_p(x) = \log_p(|x|_p) = -n$) [K73]. For rational- and even algebraic number valued probabilities this entropy can be regarded as a real number. The entropy defined in this manner can be negative so that the entanglement can carry genuine positive information. Thus p -adic bound state entanglement giving rise to a fusion of cognitive mental images is a natural correlate for the experience of understanding, and one can assign to eureka a well defined amount of information. Rationally entangled p -adic system has a positive information content only if the number of the entangled state pairs is proportional to a positive power of the p -adic prime p .

2. This kind of definition of entropy works also in the real-rational and even real-algebraic cases and makes always sense for finite real world ensembles and for entanglement between real (p -adic) systems. Entanglement probabilities are indeed algebraic numbers for both rational and algebraic entanglement coefficients. Here the problem is how to fix the value of the prime p and the only reasonable criterion is maximization of information.
3. The modified definition of entropy would have deep implications. For the ordinary definition of the entropy NMP [K73] states that real entanglement is minimized in the state preparation process. For the number theoretic definition of entanglement entropy NMP stabilizes the entanglement with positive information content. The fragility of quantum coherence is the basic problem of quantum computation and the good news would be that Nature itself (according to TGD) tends to stabilize quantum coherence if entanglement is rational/algebraic.

Weak form of NMP which allows non-maximal negentropy gain allows also a further maximization of negentropy gain. The price paid is that the world is not the best possible one: conscious entities get free will and can make also choices reducing the negentropic resources of the Universe. These deviations are however analogous to thermodynamical fluctuations and the statistical trend is that world gets a better place in that its negentropy increases. An interesting question which I remember of having encountered in a russian scifi book (do not remember its author) is whether second law could actually reflect also the presence of an intentional bad will? What is especially nice is that the weak form of NMP predicts generalization of p -adic length scale hypothesis which I ended up from p -adic mass calculations.

NMP and negentropic entanglement demanding entanglement probabilities which are equal to inverse of integer, is the starting point. Rational and even algebraic entanglement coefficients make sense in the intersection of real and p -adic worlds, which suggests that in some sense life and conscious intelligence reside in the intersection of the real and p -adic worlds.

What could be this intersection of realities and p -adicities?

1. The facts that fermionic oscillator operators are correlates for Boolean cognition and that induced spinor fields are restricted to string world sheets and partonic 2-surfaces suggests that the intersection consists of these 2-surfaces.
2. Strong form of holography allows a rather elegant adelization of TGD by a construction of space-time surfaces by algebraic continuations of these 2-surfaces defined by parameters in algebraic extension of rationals inducing that for various p -adic number fields to real or p -adic number fields. Scattering amplitudes could be defined also by a similar algebraic continuation. By conformal invariance the conformal moduli characterizing the 2-surfaces would be defined by the parameters.

This suggests a rather concrete view about the fundamental quantum correlates of life and intelligence.

1. For the minimal option life would be effectively 2-dimensional phenomenon and essentially a boundary phenomenon as also number theoretical criticality suggests. There are good reasons to expect that only the data from the intersection of real and p -adic string world sheets partonic two-surfaces appears in U -matrix so that the data localizable to strings connecting partonic 2-surfaces would dictate the scattering amplitudes.

A good guess is that algebraic entanglement is essential for quantum computation, which therefore might correspond to a conscious process. Hence cognition could be seen as a quantum

computation like process, a more appropriate term being quantum problem solving [K3]. Living-dead dichotomy could correspond to rational-irrational or to algebraic-transcendental dichotomy: this at least when life is interpreted as intelligent life. Life would in a well defined sense correspond to islands of rationality/algebraicity in the seas of real and p-adic continua. Life as a critical phenomenon in the number theoretical sense would be one aspect of quantum criticality of TGD Universe besides the criticality of the space-time dynamics and the criticality with respect to phase transitions changing the value of Planck constant and other more familiar criticalities. How closely these criticalities relate remains an open question [K101].

The view about the crucial role of rational and algebraic numbers as far as intelligent life is considered, could have been guessed on very general grounds from the analogy with the orbits of a dynamical system. Rational numbers allow a predictable periodic decimal/pinary expansion and are analogous to one-dimensional periodic orbits. Algebraic numbers are related to rationals by a finite number of algebraic operations and are intermediate between periodic and chaotic orbits allowing an interpretation as an element in an algebraic extension of any p-adic number field. The projections of the orbit to various coordinate directions of the algebraic extension represent now periodic orbits. The decimal/pinary expansions of transcendentals are un-predictable being analogous to chaotic orbits. The special role of rational and algebraic numbers was realized already by Pythagoras, and the fact that the ratios for the frequencies of the musical scale are rationals supports the special nature of rational and algebraic numbers. The special nature of the Golden Mean, which involves $\sqrt{5}$, conforms the view that algebraic numbers rather than only rationals are essential for life.

Later progress in understanding of quantum TGD allows to refine and simplify this view dramatically. The idea about p-adic-to-real transition for space-time sheets as a correlate for the transformation of intention to action has turned out to be un-necessary and also hard to realize mathematically. In adelic vision real and p-adic numbers are aspects of existence in all length scales and mean that cognition is present at all levels rather than emerging. Intentions have interpretation in terms of state function reductions in ZEO and there is no need to identify p-adic space-time sheets as their correlates.

Quantum computation and quantum problem solving in TGD Universe

Macro-temporal quantum coherence makes also quantum computation like processes possible since a sequence of quantum jumps effectively binds to a single quantum jump with a duration, which corresponds to the lifetime of the bound state. Quantum computation like process starts, when the quantum bound state is generated and halts when it decays. Spin glass degeneracy increases the duration of the quantum computation to time scales which are sensical for human consciousness. In case of cognitive quantum computation like processes the quantum coherence is stabilized by NMP.

1. Spin glass degeneracy provides the needed huge number of degrees of freedom making quantum computations very effective. These degrees of freedom are associated with the join along boundaries bonds/flux tubes and are essentially gravitational so that a connection with Penrose-Hameroff hypothesis emerges.
2. Bio-systems would be especially attractive candidates for performers of both non-cognitive and cognitive quantum computation like processes. The binding of molecules by lock and key mechanism is a basic process in living matter and the binding of information molecules to receptors is a special case of this process. All these processes would involve new physics not taken into account in the standard physics based biochemistry.
3. The possibility of cognitive quantum computation like information processing forces generalize the standard quantum computer paradigm also because ordinary quantum computers represent only the lowest, 2-adic level of the p-adic intelligence. Qubits must be replaced by qupits since for algebraic $R - R_p$ entanglement two-state systems are naturally replaced with p-state systems and for $R_{p_1} - R_{p_2}$ entanglement with $p_1 \times p_2$ state systems. For primes of order say $p \simeq 2^{167}$ (the size of small bacterium) this means about 167 bits, which means gigantic quantum computational resources. The secondary p-adic time scale $T_2(127) \simeq .1$

seconds basic bit-like unit corresponds to $M_{127} = 2^{127} - 1$ M_{127} -qubits making about 254 bits. The idea about neuron as a classical bit might be a little bit wrong!

4. It might be more appropriate to talk about conscious problem solving instead of quantum computation. In this framework the periods of macro-temporal quantum coherence replace the unitary time evolutions at the gates of the quantum computer as the basic information processing units and entanglement bridges between selves act as basic quantum communication units with the sharing of mental images providing a communication mode not possible in standard quantum mechanics.

Quantum-classical correspondence suggests that the notion of information is well defined also at the space-time level. The non-determinism of Kähler action and p-adic non-determinism plus algebraic information measures suggest a natural approach to the problem of defining the information concept. This approach provides also a new light to the problem of assigning a p-adic prime to a given real space-time sheet.

Information concept at space-time level

For years ago I ended up with the idea that space-time surface should somehow code for the preferred p-adic primes so that it would be a representations for an integer and considered some naïve proposals how this could be realized. Since the ramified primes identifiable as preferred p-adic primes characterize the algebraic extension of rationals assignable to string world sheets and partonic 2-surfaces defining “space-time genes” - or more precisely, the ideal for algebraic extension - to which the parameters characterizing string world sheets and partonic 2-surfaces belong, they characterize by strong form of holography also the space-time region containing them. In fact, the integer defined by the product of ramified primes characterizes the space-time region.

One can say that in very abstract sense space-time region represents factorization of integer and p-adic space-time region corresponding to ramified primes define a similar adelic factorization. The reason for the preferred character of the ramified primes is that for them n separate space-time surfaces obtained by the action of Galois group on the parameters of 2-surfaces coincide at the boundaries of CD (criticality!) so that one obtains analog of bound state [K140]. The different branches correspond to n discrete of freedom, and one can assign to them many-fermion states: at most 1 fermion at single sheet of the covering.

2.5.2 Thermodynamical Aspects

During macro-temporal quantum coherence dissipation is absent in the quantum coherent degrees of freedom. This suggests the breaking of the second law of thermodynamics in time scales shorter than the duration of bound states in the sense that entropy does not grow. [It is also possible that the geometric arrow of psychological time is reversed at the space-time sheets having negative time orientation: in this case second law holds true with respect to subjective time but corresponds to a decrease of entropy with respect to the geometric time of the external observer.]

p-Adic length scale hypothesis suggests a hierarchy of time scales for bound state lifetimes so that a hierarchical structure for the breaking of the second law is predicted. At space-time sheet characterized by p-adic prime p the second law would be broken below the time scale $T_p = L_p/c$, $L_p = \sqrt{p} \times l_0$, where l_0 is essentially CP_2 length scale about 10^4 Planck lengths. Breaking could also occur only below n-ary p-adic time scales $T_p(n) = p^{(n-1)/2} L_p$.

Quite recently it has been found that second law is indeed broken below .1 seconds for certain systems [D18]. This time scale corresponds to the secondary p-adic time scale $T_p(2)$ associated with the Mersenne prime $M_{127} = 2^{127} - 1$ defining the p-adic length scale of electron. This time scale is fundamental in the TGD based model of living system and corresponds to the time scale of alpha band and the time resolution of the sensory experience (duration of sensory mental images). The reversal of the arrow of geometric time below p-adic time scale might be fundamental aspect of living systems and this point will be discussed later in more detail.

The recent view about NMP suggests strongly breaking of second law. The breaking however is due to the generation of negentropic entanglement stable under NMP (or more precisely under weak form of NMP which does not require maximal negentropy gain in state function reductions and in this manner allows free will). Entanglement negentropy (number theoretic Shannon entropy

[K73]) tends to increase by NMP - also for weak form of NMP but in statistical sense. Number theoretic negentropy is however not equivalent with thermodynamical entropy which characterizes average member of ensemble rather than the pair formed by system and its complement so that second law need not be broken. An essential point is that the density matrix is projector for negentropically entangled states and the corresponding entanglement matrix is unitary matrix.

However, in a phase transition transforming thermal ensemble to negentropically entangled state, second law is broken. A more precise formulation for the second law would be that it holds for visible matter in processes in which visible matter does not transform permanently to dark matter. In order to test the TGD version of second law, or rather NMP, one should be able to detect and manipulate dark matter. Quantum criticality are ideal tool to generate dark matter phases. This might be possible even in thermodynamically critical systems, which are indeed problematic from the point of view of thermodynamic description.

2.5.3 Energetic Aspects

The vision about energetic aspects of quantum coherence as evolved gradually.

1. The generation of quantum bound state involves liberation of the binding energy as a usable energy. This might provide a new kind of metabolic mechanism in which co-operation by the formation of macroscopic quantum bound states allows a liberation of metabolic energy. The energy bill must be paid sooner or later, and the energy feed from environment takes care of this by destroying the bound state in average time defined by the duration of the bound state. The fact that oxidative metabolism is anomalously low during the neuronal synchrony [J54] supports the view that neuronal synchrony might give rise to bound-state entangled multineuron states. This mechanism is quite general and even ordinary metabolism could be based on this mechanism as will be proposed later. Also the bound state entanglement between different organisms might be possible and liberate energy. Thus the notion of "synergy" might be much more than a mere metaphor.
2. Later the notion of negentropic entanglement emerged. Entanglement negentropy tends to increase by NMP and it is not at all clear whether there is any need to assume that there is any binding energy involved. One could even play with metaphors and consider the possibility that NE is like genuine love: it keeps people together without any violence as in organized marriage. Negentropic entanglement is very special: density matrix is projector so that its occurrence in standard quantum theory is extremely implausible. Even slightest perturbation can destroy it. In TGD framework however the hierarchy of Planck constants accompanied by n-sheeted coverings predicts it and NMP not only stabilizes it but favors its generation. As a matter of fact, negentropic entanglement is the essence of quantum criticality.

NMP leads also to the vision that metabolism is basically transfer of NE. This applies not only to energy metabolism but also to other forms of metabolism. Living systems must be able to generate NE to satisfy the demands of NMP. They can get NE by stealing the NE generated by other living systems - that is by eating them - One manner is to generate it by the Karma's cycle of mental images (subelves) in which subelves are repeatedly born, live by performing a sequence of repeated state function reductions at the same boundary of CD (Zeno effect) and die as they perform the first reduction to the opposite boundary of CD and re-incarnate as a time-reversed mental image at the opposite boundary. Sensory-motor cycle would be fundamental realization of this cycle.

2.6 Macro-Temporal Quantum Coherence, Consciousness, And Biology

This section is devoted to a brief discussion of the aspects of macro-temporal quantum coherence related to consciousness and biology.

2.6.1 Macro-Temporal Quantum Coherence And Biology

The increase of Planck constant as reduction of quantum criticality transforming supersymplectic gauge degrees of freedom to dynamical ones is a generic mechanism for generating new quantum fluctuating degrees of freedom. This process occurs spontaneously and generation of NE accompanies this process.

Living systems are however doing their best to keep their level of quantum criticality rather allowing spontaneous increase of h_{eff} . The paradoxical looking behavior is created by the fact that the generation of NE and phase transition increasing h_{eff} is associated with the first state function reduction to the opposite boundary of CD. This means death of self followed by a re-incarnation at opposite boundary. Selves are doing their best to avoid this and at the same time give for the sub-selves (mental images) opportunity to long Karma's cycle leading to a high negentropy gain.

Metabolic energy transfer and other forms of metabolism can be seen as mechanisms allowing to steal existing negentropy resources in order to avoid the unavoidable forced eventually by NMP. Also homeostasis can be seen as a collection of mechanisms allowing to keep the existing level of criticality.

At the macro-level sexual organism could be a basic example of a multi-verse state of oneness generated by the formation of a macroscopic quantum bound state of partners. Neuroscientists are used to talk about rewards and punishments, and one might argue that life involves kind of sexual or spiritual pleasure as a reward for the formation of bound states at all levels of hierarchy. Spiritual experiences would represent the most abstract experiences of this kind involving the formation of bound states of the field bodies by MEs serving as field bridges.

Some examples are in order.

- (a) The binding of molecules by lock and key mechanism is a fundamental process in living matter. The first idea to come in mind is that it could generate large number of quantum fluctuating degrees of freedom and generate conscious intelligence. This could explain why long linear macro-molecules are so important for life. From the viewpoint of classical chemistry it is not obvious why DNA is arranged into long chromosomes rather than separate short threads. In TGD universe the reason why would be that for chromosomes the number of quantum fluctuating degrees of freedom and thus the amount of conscious intelligence is maximized.
- (b) It however seems that biochemistry is not enough. Also the notion of magnetic body is needed and topological field quantization provides it: the essential point is that physical systems in TGD Universe have also field identify unlike in Maxwellian theory. Magnetic flux tubes of magnetic bodies carrying dark matter could be the manner how living matter generates negentropic entanglement. Living matter could have a network of magnetic flux tubes analogous to a coordinate grid making it a coherent structure. Magnetic flux tubes would connect molecules and even larger structures to connected networks. One can imagine several mechanisms involving flux tubes and dark photons at them.
 - i. The reduction of Planck constant for magnetic flux tubes brings the molecules near to each other in the molecular crowd and makes possible the occurrence of various biochemical reactions such as replication of DNA, transcription, and translation of mRNA to proteins. The dark cyclotron photons at flux tubes provide a fundamental communication and control mechanism.
 - ii. Besides h_{eff} changing phase transitions, reconnection of flux tubes is a key process. For instance, the basic mechanism of attention could be reconnection for U-shaped flux tubes forming a flux tube pair connecting to molecules or larger systems.
 - iii. A further key process would be replication of magnetic bodies serving as templates of organisms. This replication is completely analogous to what happens in 3-vertex of Feynman diagram. Visible living matter would self-organize around

magnetic bodies carrying dark matter and even basic biopolymers (DNA, mRNA, and amino-acid sequences) would have dark counterparts realized as dark proton sequences at dark magnetic flux tubes parallel to the visible part of biopolymer.

- iv. Cyclotron resonance for dark cyclotron photons propagating parallel to flux tubes would be a key mechanism of communication and control and bio-photons could be seen as ordinary photons resulting from dark photons in Planck constant reducing transformations. For instance, EEG could consist of dark photons at EEG frequencies but energies at visible photon energies.
- (c) The binding of the information molecules to receptors is a universal control mechanism in the living matter. In TGD universe information molecule would initiate genuine quantum information processing lasting for the lifetime of the information molecule-receptor complex. In particular, neurotransmitters could induce molecular states of one-ness in the receptor-neurotransmitter complex or perhaps even in larger-sized structures. If neurotransmitters have flux tubes to other neurons mediated by magnetic flux tube structures or MEs, they could act as conscious quantum links in quantum web and induce quantum computation like processes involving distant neurons just as the links in the web induce classical computations involving distance computers.
- (d) One could even see information molecules and receptors as representatives of opposite molecular sexes: information molecules would be active quantum binders free to move from flower to flower whereas receptors would be the passive party attached to some structure. The binding of the information molecule to the receptor would be the molecular analog of the sexual intercourse. Usually the receptors are bound to larger structures such as cell membrane and also the zero modes for some parts of these larger structures could become quantum fluctuating in the process.
- (e) As found, the new number-theoretic definition of entropy is very attractive from the point of view of consciousness theory also in the real context. An especially interesting biological application of the number-theoretic entropy would be to the genetic code: in this case the number of bases is proportional to at least $p = 3$. Does the number N of DNA triplets of gene or of information bearing fragments of gene have a tendency to be proportional to powers of some relatively large primes? Could one order the genes hierarchically by the prime number decomposition of the number N so that large primes would correspond to high level bio-control and small primes to low level bio-control? Could the prime number decomposition of N define natural decompositions of gene to sub-modules of the biological program defined by the gene? For instance, $N = 10 = 2 \times 5$ would correspond to 5 (2) sub-modules consisting of 2 (5) DNA triplets.

2.6.2 Macro-Temporal Quantum Coherence And Long Term Memory

The energies liberated in the transitions between spin glass states should correspond to gravitational binding energies. MEs would be the space-time correlates for the radiation emitted in these transitions. These MEs are very near to vacuum extremals and in the simplest situation have CP_2 projection belonging to a homologically trivial geodesic sphere of CP_2 . They would carry vanishing induced Kähler fields (U(1) field in standard model). Another basic kind of MEs would carry classical em, W fields, and gravitational fields and would correspond to CP_2 projection in homologically non-trivial geodesic sphere. The transitions for MEs near vacuum extremals could realize the mirror mechanism of long term memories.

It is now clear that MEs are double sheeted at least: quite generally, the two sheets are connected by a pair of wormhole throats defining the elementary particle in question. This applied in the case of photons too.

A few years old realization [K142] is that the condition that the em charge of induced spinor modes is well-defined forces them in the generic case to string world sheets carrying vanishing W gauge fields and in suitable gauge also W gauge potentials. The interpretation is in terms

of strong holography. The string world sheets and partonic 2-surface which they intersect at discrete points carry the information needed to build quantum states in ZEO. Induced spinor fields would not feel the presence W fields at all but just the condition that this is the case would determine the dynamics of string world sheets! Avoidance behavior implies also strong correlation with that which causes avoidance behavior! The fundamental 2-surfaces provide also the basic understanding in living matter.

Mirror mechanism of long term memories and topological light rays

To remember what happened (more precisely, happens subjectively now) in the geometric past at a temporal distance of one year is to look at a quantum mirror at a distance of one half light year. To have an intention is to look at a p-adic quantum mirror which is in the geometric future.

Dark MEs (topological light rays) with fundamental frequencies with a time scale measured using year as a natural unit are needed in the mirror model of human long term memories. Most naturally MEs correspond to dark photons. The original belief was that only gravitonic MEs should be considered. Here the problem is that amplitudes for the generation gravitons are incredibly weak unless one has macroscopic quantum coherence replacing the factor N (number of emitters) with N^2 . This of course occurs also for the electromagnetic case. In any case, the macroscopic coherence for gravitation emission implies it also for em emission.

The electromagnetic between a huge number of almost degenerate spin glass states could be coded to the fundamental frequencies of MEs. The value of Planck constant $\hbar_{gr} = GMm/v_0$ would be large but for m in the mass range of elementary particles and atomic and molecular structures $\hbar_{eff} = \hbar_{gr}$ would be consistent with the values of \hbar_{eff} proposed to be realized in living matter.

In particular, structures with sizes slightly above cell membrane thickness, such as micro-tubules, could generate MEs as a topological correlate for dark photon emission with frequency (length) of ME equal to the increment of the gravitational binding energy in quantum jump involved. Thus there would be a direct correlation with long term memories and micro-tubules: micro-tubule conformations could code for long term memories.

The mirror mechanism of long term memory allows a beautiful interpretation in terms of topological correlates for virtual gauge boson exchange with vacuum.

- (a) The light reflected in mirror corresponds to topological light rays assignable to photons and is reflected from the curved vacuum. Topological counterpart of virtual photon is emitted by (say) a tubulin, reflected by the vacuum, and finally absorbed by the tubulin. Curved vacuum acts as a mirror for photons and self can see the self of the geometric past in this mirror.
- (b) One could interpret the low energy topological light rays responsible for long term memory as a particular kind of $1/f$ noise accompanying all critical systems, in particular TGD Universe, which can be regarded as a quantum critical quantum spin glass. Dark photon $1/f$ noise would be emitted in the transitions between almost degenerate spin glass states and would be kind of analog for brehmstrahlung.

If this view is correct, the time scales of long term memory at DNA level would correspond to very long time scales characterizing consciousness at the level of species. This in fact conforms with the role of DNA as a species memory. Interestingly, the gravitational binding energy associated with $L(139) \sim .1$ nm (atomic physics) corresponds to the age of the universe: perhaps this explains why Schrödinger equation applies to the description of atom. $1/R$ dependence of the gravitational interaction energy would explain why very short length scales code biological information about very long time scales rather than vice versa.

Order of magnitude estimate for gravitational binding energies

A rough order of magnitude estimate for the gravitational binding energy for a cubic blob of water (that is living matter) having size given by scaled up electron Compton length $L_e(k)$ is

$$E_{gr} \sim \frac{GM^2}{L_e(k)} = G\rho^2 L_e(k)^5 \sim \frac{Gm_p^2}{L_e(137)} \frac{L_e(k)}{L_e(137)^5} \simeq 2^{-127} 2^{5/2(k-137)} \frac{1}{L_e(137)} .$$

Gravitational binding energy is larger than the p-adic energy $\pi/L_e(k)$ for $L_e(k = 179) \simeq .169$ mm. In the range $L_e(163) = 640$ nm and $L_e(167) = 2.56 \mu m$ gravitational binding frequency varies between 1 Hz and 1 kHz, that is over EEG range up to the maximal frequency of nerve pulses. If the binding energy gives estimate for the lifetime of the gravitationally bound states, this might fit nicely with EEG energies in typical cell length scales!

For $k = 157$ and $k = 151$ (the range from cell 10 nm-80 nm, micro-tubules are at the lower end of this range) the gravitational binding frequency corresponds to a time scale of 8.5 hours and 32 years respectively so that the time scales relevant for life are spanned by the Gaussian Mersennes. What sounds paradoxical is that short length scales would correspond to long time scales but this indeed follows from the inverse square law for the gravitational force.

One can perform a similar estimate for linear structures. Parameterizing the micro-tubular transversal area to be $d = x^2 L_e^2(151)$, $L_e(151) = 10$ nm, one has

$$E_{gr}(lin, k) = x^5 \times E_{gr}(cubic, 151) \frac{L_e(k)}{L_e(151)} .$$

This gives for $L_e(k) \sim 1$ meter, the frequency of $.1 \times x^5$ Hz. The time scale varies between $10/x^5$ seconds and $32/x^5$ years and certainly covers the time scale for human long term memories. Of course, this rough estimate involves numerical factor which can increase the upper bound. One must also remember that the change of the classical gravitational energy for spin glass transitions is in question and this energy is smaller than binding energy itself so that actual time scales are considerably longer.

Together with the known facts about the correlations of micro-tubuli with long term memories this leads to the idea that micro-tubuli represent long term memories. What is so beautiful in this idea is that there is no need for long term static storage of memories since memory is represented in the geometric past. The instantaneous configurations of the micro-tubuli define the memories and they are allowed to change in quite rapid time scales. The two conformations of tubulin dimers are ideal for representing declarative memories as bit sequences and micro-tubuli provide huge information storage capacities. One can also understand why sensory pathways tend to maximize their length. The loss of long term memories at old age respects the oldest memories and this naturally corresponds to the degeneration of the long micro-tubuli first with shortest micro-tubuli being the most stable ones. In [K99] the model for long term memories is developed in detail.

2.7 Co-Operation And Competition As Different Aspects Of Quantum Consciousness

2.7.1 Breaking Of Super-Conductivity, Metabolism And Homeostasis

The assumption that magnetic flux tubes of say Earth's magnetic field serve as carriers of supra currents in living manner leads to concrete views about breaking of super-conductivity as a basic mechanism of metabolism and homeostatic control.

Leakage mechanism

The basic mechanism for the breaking of super-conductivity is the generation of “bridges” between super-conducting magnetic flux tubes and some smaller space-time sheets, which need not be atomic space-time sheets as assumed in the earlier formulation of the model. The energy of photons inducing the bridges corresponds naturally to the difference for the energies of the ion at atomic space-time sheet and super-conducting magnetic flux tube. In the case that the energy at magnetic flux tube is very small as compared to the zero point kinetic energy at smaller space-time sheet, the energy of photon must be the zero point kinetic energy at least. This option will be discussed in the sequel. The ions at the smaller space-time sheet dissipate their energy and end up to having only zero point kinetic energy plus possible thermal energy.

Quantum-classical correspondence suggests that it should be possible to understand how the absorption of photons corresponds to the process in which “bridges” are generated by MEs. MEs carry transversal electric and magnetic fields. There is infinity variety of various kinds of MEs but for the simplest MEs electric and magnetic fields have constant linear direction orthogonal to each. Electric field defines a potential difference which is constant in length scales much shorter than the wave length of ME. By generalizing the quantization of magnetic flux to that for electric flux one obtains that the potential difference satisfies

$$eV = n\omega = nf \times 2\pi .$$

This means that an ion having a charge e accelerating in the radial field gets energy $E = n\omega$. Thus absorption of photon with energy $n\omega$ corresponds classically to an acceleration in the electric field of ME and getting same energy. For ion having opposite charge acceleration would be replaced by deceleration and one must speak of emission of photon with energy $E = n\omega$. The model for ADP-ATP process is indeed based on the assumption that metabolic energy generates an electric potential in which protons are accelerated to get energy of .5 eV. for TGD based model see [K62]).

New manner to interpret gap energy of bio-super-conductor

The values of the gap energies of super conductors are identifiable as differences of zero point kinetic energies for the space-time sheets, which correspond to the value of p-adic prime nearest to that associated with the magnetic flux tubes in question and present in the topological condensate. For Earth’s magnetic field one has $k = 169$ from flux quantization. For proton the zero point kinetic energy at $k = 151$ space-time sheet is about $E_0 = 2^{137-151} \times .5$ eV, which corresponds to a critical temperature of about $T_{cr} \sim E_0 = .3$ K. For $k = 149$ the critical temperature is about 1.2 K. For $k = 139$ the critical temperature would be 1250 K. If this picture is correct, high T_c super conductors result, when the intermediate space-time sheets between those representing super-conducting magnetic flux tubes and atomic space-time sheets are eliminated somehow from the material. This goal could be achieved by using strong enough magnetic fields for which the p-adic prime is larger than $k = 151$ so that there are not so many p-adic primes to be eliminated. Also secondary p-adic primes are allowed. For instance, $L_2(71)$ *resp.* $L_3(37)$ corresponds effectively to $k = 142$ *resp.* $k = 141$ and critical temperature of 156 K *resp.* 312 K.

The new view about metabolism

This picture about breaking of bio-super-conductivity leads to a new view about metabolism. .5 eV is the value of the quantum of metabolic energy and corresponds to the zero point kinetic energy of proton. The interpretation is that this energy is the minimum energy needed to kick proton from magnetic flux tube of the Earth’s magnetic field (say) to the atomic space-time sheets and is liberated in the reverse process. Irradiation by coherent IR photons with energy of .5 eV induces both the formation of the bridges making possible the transfer of protons to atomic space-time sheet and dropping them back. The first process is like pumping of atoms

to excited states and the second process is like laser emission of coherent light amplified by the presence of IR photons (also absorption of negative energy photons could be involved as will be discussed below). The process is also accompanied by cyclotron radiation (scaling law of homeopathy). When glucose is metabolized IR photons of energy of 5 eV are liberated and these photons induce both pumping and induced emission. This process involves the $F_0 - F_1$ machine responsible for the metabolic control. Phase conjugates of IR laser waves should reverse the functioning of $F_0 - F_1$ machine if this view is correct.

Also other ions, even electrons, can be involved in this kind of metabolic cycles and the process can occur between other pairs of space-time sheets. For instance, $k = 151$ space-time sheets microwave photons could induce similar metabolic cycle for protons or of their Cooper pairs and also other ions. The value of the zero point kinetic energy depends on the details of the local environment and this would make possible very effective control of the process. For a given microwave energy the ions associated with only particular kind of the molecular environment would participate in the cycle. Thus microwaves could make possible very precise quantum control. The inducing microwaves could be emitted by the conformational transitions of proteins and other bio-molecules and this would make possible precise and selective bio-control from protein level since the thermal widths of states would be extremely narrow at $k = 151$ space-time sheet. The phase conjugates of microwaves would induce the time reversal of this process making possible healing by time reversal of the biological programs. This would boil down to a very elegant and economical control of the metabolism and homeostasis combining both many-sheeted laser physics and super-conductivity. The analysis of the findings of P. Gariaev's group [I85] suggests that biological microwave lasers are only example of bio-lasers.

Many-sheeted laser action

There is strong analogy with the functioning of laser. The transfer of ions to smaller space-time sheets is analogous to the pumping of atoms to higher energy state. The presence of coherent photons at this energy implies also the many-sheeted analog of the induced emission: the ions having only thermal energy drop back to the magnetic flux tube by emitting photon at energy corresponding to the zero point kinetic energy. If the energy obtained in the kicking is exactly the zero point kinetic energy and the smaller space-time sheet is very cold no dissipation occurs and the situation is especially favorable for laser action.

The irradiation of system with phase conjugate beam of coherent light at this frequency could help to restore the super-conductivity: this hypothesis might be tested for high T_c super-conductors, which might be based on the same mechanism as bio-super-conductors [K23, K24].

The special role of microwave photons in homeostasis

Microwaves are certainly not the only players in homeostasis but it seems that they have a special role. Plasmoids consisting of closed magnetic flux tube structures carrying supra currents plus atomic space-time sheets associated with them, are good candidates for primitive electromagnetic life-forms. Ordinary bio-matter is assumed to self-organize around these structures and nerve circuit represents a good example of a structure resulting in this manner.

Plasma balls are known to be accompanied by microwaves. This suggests that microwave photons could induce these bridges, break super-conductivity, and induce energy feed and self-organization. A similar breaking of super-conductivity might be also involved with the driving of the super-conducting ions to the atomic space-time sheets in the living matter. It is also possible that the process does not involve much dissipation ($k = 151$ space-time sheet should be very cold and in this case many-sheeted maser would result).

There are several candidates for the source of microwaves in case of plasmoids. What makes these sources so interesting from the point of view of biology is that the frequency spectrum is almost universal.

- (a) For instance, the ionic currents between $k = 151$ space-time sheets and Earth's magnetic flux tubes makes possible masers. The dropping of electron Cooper pairs from $k = 157$ space-time gives rise to microwave photons with energy about 10^{-3} eV, wavelength of 1.24 mm. More generally, the frequency is $f(A, k) = 2^{157-k} \times .25$ GHz with the assumption that the size of space-time sheet is given by $L(k)$. The dropping of ion of mass number A from space-time sheet k gives rise to photons with frequencies $f(k) = 2^{151-k} \times .15/A$ GHz frequency.

In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant \hbar_{eff} so that cyclotron energy would be liberated. In the following only the “dropping” option is discussed.

- (b) The multiple-coiled structure of DNA is expected to give rise to a hierarchy of magnetic flux tubes, and cyclotron transitions at these magnetic flux tubes serve as sources of microwaves. Electronic cyclotron frequency, assuming p-adic scaling of the Earth's magnetic field strength ($k = 169$), is equal to $f_e(k) = 2^{163-k} \times .038$ GHz, whereas ionic cyclotron frequency is $f_c(A, k) = 2^{151-k} \times .8/A$ GHz. As will be found, the transitions between cyclotron states at different space-time sheets allow to understand the radio-wave emission from DNA induced by laser light.

There are also more conventional sources of microwaves.

- (a) Coherently occurring protein conformational transitions could generate microwaves and could be also amplified by the many-sheeted masers. Also molecular masers are possible (say OH maser).
- (b) The rotational transitions of clusters of water molecules could emit microwaves and perhaps mimic and amplify the microwaves generated by proteins. The clusters of water molecules forming liquid crystals can mimic the conformational and rotational spectrum of various molecules, and that the ability to reproduce the rotational frequency spectrum of the medicine molecule is an essential element of homeopathic healing. The level of self-organization of water would thus be measured by how complex mimicry it is able to perform.

Why rotational microwave energy spectrum is so important for healing, might be understood as follows. The many-sheeted current circuitry, involving atomic space-time sheets and magnetic flux tubes and also other space-time sheets, is extremely complex control structure [K87, K86]. The continual regeneration of bridges between, say, atomic space-time sheets and magnetic flux tubes by microwaves emitted by proteins is necessary to sustain this circuitry. An important category of diseases is due to the failure to generate the bridges between super-conducting and atomic space-time sheets so that this control circuitry suffers shortcuts. Perhaps the genetic expression of some proteins responsible for the microwaves generating particular bridges fails. The medicine or its homeopathic counterpart would help to generate (or even re-establish the generation of) the microwave spectrum responsible for the generation of the lacking bridges in the circuitry.

2.7.2 Combining Macro-Temporal Quantum Coherence And Dissipation

The question is how the saint and sinner aspects combine. The needed piece of the puzzle comes from the scaling law of homeopathy [K58]. The law states that high and low frequencies accompany each other, the frequency ratio being $f_{high}/f_{low} \simeq 2 \times 10^{11}$ in the simplest

situation when the ions leak to atomic space-time sheet from the magnetic flux tubes of Earth's magnetic field. The ratio is essentially the ratio of zero point kinetic energy of the ion at the smaller space-time sheet and the cyclotron energy of the ion at magnetic flux tube. Radiation with frequency f_{high} is produced when ions drop to the magnetic flux tube. The ions drop to cyclotron states such that the magnetic quantum number n is usually larger than $n = 0$, which in turn decay and produce cyclotron radiation with frequency f_{low} and its harmonics.

The TGD based interpretation is that ELF MEs are responsible for quantum entanglement in macroscopic, even astrophysical, length scales. Microwave MEs propagating effectively as mass-less particles along ELF MEs in turn induce self-organization by serving effectively as "food" of the plasmonic life forms at the receiving end. This mechanism is behind both the endo- and exogenous realizations of intentions as actions, that is ordinary motor actions and phenomena like remote healing and psychokinesis. Also sensory representations at the personal magnetic canvas and magnetosphere rely on this mechanism, and in this case life-forms are mental images getting at least partially their metabolic energy from brain. The law generalizes also to pairs formed by kHz radio wave MEs and MEs corresponding to visible light.

2.7.3 Healing By Time Reversal

I have proposed in [K97] that time reversal is the basic mechanism of healing. The biological programs simply run backwards to the point, where the error occurred, and a new trial is made. De-differentiation is the counterpart of this mechanism at the cellular level. Stem cells are indeed increasingly used for healing purposes, leukemia being one example of this. The following arguments inspire the question whether biological rhythms could quite generally correspond to dissipation-healing (by time reversal) cycles.

The following considerations reflect the situation for about 15 years ago and the examples represent "fringe physics". I hope that this does not mask the generality of the mechanism of healing about which I had no idea when the following sections were written.

Priore's machine

The TGD based model [K97] of Priore's machine [I140, I45] is based on this idea and involves phase conjugates of microwaves perhaps inducing time reversal mode of molecular machines at DNA level and thus leading to the correction of the genetic error responsible for the cancer. Irradiation by phase conjugate microwaves at critical frequencies might induce the time reversed mode and thus provide a possible general healing mechanism affecting directly the DNA level. Later an alternative interpretation for the functioning of Priore's machines as a mechanism of "stealing" metabolic energy from the cancer cells will be proposed.

Searl machine

The work with various anomalies involved with free energy phenomena has revealed a deep connection between quantum bio-control, remote mental interactions, and free energy phenomena. This connection has become especially clear during the development of a model for so called Searl machine [H9, H18] (see [K131]). Needless to say that academic physicists do not take Searl machine seriously: this would be quite too dangerous for the career. Personally I do not believe or not-believe in it, and just admit that it might involved the notions of magnetic body, generation of dark matter, and quantum criticality in very interesting manner.

Searl machine involves stationary ring magnet along which smaller cylindrical magnets spontaneously start to rotate provided the parameters of the system are in suitable range. Several anomalous effects are involved: weight loss, over unity energy production, generation of magnetic walls, generation of plasma phase, effects on radio-active decay rates, and strong parity breaking.

The TGD based model of the Searl effect is based on essentially the same mechanisms as applied in the quantum models for homeostasis and remote mental interactions [K58].

Several new physics effects seem to be involved.

- (a) The rotating magnetic system develops em and Z^0 charges and experiences the classical em and Z^0 electric forces created by Earth so that the effective weight is reduced or increases (depending on the direction of rotation) as much as 35 per cent. The charging is due to the flow of electrons and neutrinos from the rolling magnets to the surrounding air induced by the radial electric and Z^0 electric fields generated by the Faraday effect inducing vacuum charge density (not possible in Maxwell's electrodynamics). The fact that critical frequencies are different for clockwise and counter clockwise spontaneous rotation implies that classical Z^0 force and neutrino currents must be present.
- (b) The spontaneous accelerating rotation above critical frequency can be understood as being to a Lorentz torque acting on the radial Ohmic em and Z^0 currents in rollers and roller ring. Above the critical frequency the Lorentz torque, which is proportional to rotation frequency, becomes larger than frictional torque, and spontaneous accelerating rotation becomes possible due to the positive feedback.
- (c) The radial ohmic current of electrons leaking from the atomic space-time sheets of rollers to the space-time sheet of environment explains the presence of plasma around the system. The ionization of the molecules is caused by the electrons from rollers gaining keV energy as they drop from atomic space-time sheets of rollers to the space-time sheets of the environment.
- (d) The generation of Z^0 magnetic field explains the presence of the strange magnetic walls.
- (e) A remote metabolism based on the emission of negative energy (phase conjugate) microwave photons and realized in terms of the generalized four-wave mechanism based on magnetostatic waves provides the energy needed by the accelerating system and explains the cooling of the air around the system.

For some time I believed that the reduction of the inertial mass gives rise to a spontaneous accelerated rotation of the rollers by pirouette effect: also the generation of gravitational mass was necessary in order to understand the qualitative behavior. The required reduction of inertial mass is however measured in kilograms and means generation of corresponding positive inertial mass outside the system: this seems implausible. This does not however exclude the generation of gravitational mass in a much smaller scale defined by the magnetic energy density of the magnetic walls appearing in the system.

A further interesting aspect is that the presence of ELF waves at 10 Hz implied by rotation of the Searl machine means that the interaction with the experimenter's brain might interfere with the experiment. The importance of the experimenter's intention would conform with the finding that free energy effects are not fully re-producible. This only adds to the fascination of these effect if one is ready to give up the reductionist and materialistic dogmas and accept the possibility of remote mental interactions. For instance, Searl's machine might provide be ideal for studying mind-machine interaction.

Could molecular machines act as Searl machines?

One can ask whether the time reversal of the mechanism leading to the leakage of supra currents could be central also for the functioning of bio-systems, and whether the living matter might utilize Searl effect routinely. If so, the time-reversed modes of various molecular machines such as $F_0 - F_1$ machine responsible for the metabolism (and its variants suggests by the many-sheeted space-time concept) might be a routine part of the functioning of the living matter. They would induce time reversals of biological programs and thus healing. The generation of negative energy MEs would induce bound state entanglement and the liberated binding energy would compensate the lack of the metabolic energy feed during the time reversed mode. They could also induce "anti-gravitational" effects, which together with the macroscopic quantum coherence induced by negative

energy MEs, could be an essential aspect of the locomotion of the living organism. Molecules, which have temporarily reduced their effective weights, would be ideal for the catalysis in the many-sheeted space-time. For instance, Coulomb wall could be easily circumvented by leaving the electromagnetic charge temporarily to the larger space-time sheet.

One can thus ask whether some molecular machines are actually Searl machines in their time reversed mode. For instance, the $F_0 - F_1$ machine driving protons to atomic space-time sheet from (presumably) magnetic flux tubes of Earth, is much like a power plant containing a rotating shaft. In time reversed mode, in which it acts like a motor, the shaft might have reduced effective weight. The parity breaking effect induced by the classical Z^0 force would also favor second direction for rotation, this is obviously essential in order to achieve a synchronous action.

As noticed, Searl machine could be sensitive to remote mental interactions induced by ELF ME induced entanglement. Interestingly, the rotation frequency of $F_0 - F_1$ machine is about 300 Hz, which is the cyclotron frequency of proton in Earth's magnetic field with nominal value 5 Gauss. The rate for translation of DNA is 20/s and also this is ELF frequency. The possibility of remote mental interaction in bodily length scales by ELF ME induced entanglement could be absolutely essential for the possibility to realize intention by using molecular machines.

Could biological rhythms correspond to dissipation-healing cycles?

The following argument leads to suggestion that biological rhythms quite generally correspond to dissipation-healing cycles involving time reversal in the healing period. After 15 years I would like to rephrase this in somewhat different manner: biological rhythms correspond to repeated birth and death for subselves defining mental images. These cycles occur in several length and time scales. Sensory motor rhythms, EEG rhythms, mental images popping up and dying, sleep-wake-up rhythm, even annual biorhythms, ... serve as examples. The following summary is somewhat out-of-date but I decided to keep it as such.

Time reversal means that the second law of thermodynamics is broken. Since p-adic topology does not allow ordering of events, it is natural to expect that time reversals can occur only below the time scale defined by n-ary p-adic time scale $T_n(k)$, $p \simeq 2^k$, k prime or power of prime. An especially important p-adic time scale is the secondary time scale $T_2(127) \simeq .1$ seconds associated with electron. There is already evidence for the breaking of the second law below this time scale [D18].

The time reversal for the leakage of supra currents is predicted to involve anomalous radiation. Rotating magnetic systems (Searl machine in particular) generate visible light, which must be due to the transitions of excited N_2 and N_2^+ molecules to their ground state (see [K131], [H19]). This strange radiation has no standard physics explanation. The radiation could result in a geometric time reversal of the process in which electron drops from an atomic space-time sheet by emitting its zero point kinetic energy of about 1 keV as an X ray; X ray in turn ionizes atoms of air and creates electrons, which in turn induce electronic transitions of N_2 and N_2^+ molecules to excited states. For the time reversal excitation of nitrogen molecules occurs first by emission of negative energy photons, which in turn induce geometric time reversal for the ionization process, and finally there is a single negative energy X ray inducing the dropping of electron from atomic space-time sheet to the magnetic flux tube. The system absorbs energy from the environment in this manner, breaks second law, and is able to transform thermal energy to usable energy with efficiency larger than one.

Rotating magnetic system is also found to be surrounded by a series of magnetic walls and a lowering of the temperature is observed at the magnetic "walls": a signature for the pumping of energy from environment. Anomalous radiation usually generated by ionization of air by electrons and magnetic walls with lowered temperature might be signatures of also remote healing by time reversal.

Also metabolic cycle involves the dropping of protons to some larger space-time sheet, presumably a super-conducting magnetic flux tube of Earth, and a liberation of about .5 eV zero point kinetic energy as a usable energy (the universal "energy currency"). Buy-now pay later principle and temporary time reversal could be involved also now and provide enormous flexibility (think only how easy it is to travel abroad if you have a credit card!). The molecular system utilizing the metabolic energy quantum would emit negative energy photon being thus excited to a higher energy state, and a proton at the atomic space-time would absorb the negative energy photon

and “drop” to the magnetic flux tube to be driven back by $F_0 - F_1$ machine. Thus metabolism would repeat a cycle involving dissipation and healing. Fractality suggests that other biorhythms correspond to similar dissipation-healing cycle.

Even sensory perception and motor action could be seen as time reversals of each other in a relevant time scale. Motor action would be like carving a four-dimensional statue by starting from a rough sketch and adding the details gradually. The dissipation in both ordinary and reversed direction of the geometric time would induce Darwinian selection of a final state with only a rough dependence on the details of the sketch. No detailed planning would be required. Dissipation would act as an ally instead of an enemy. Motor actions could be imagined by initiating the time reversed process, not from the muscle cells as in case of actual motor action, but from some higher level of the central nervous system and proceeding to the level of cortex. Sensory imagination would also be a process starting from some level above sensory receptors and propagate up to the cortical level: this would mean that sensory qualia would be absent. During dreaming and hallucinations sensory qualia would be assigned to the imagined experience by feedback to the primary sensory organs involving entanglement and sharing of mental images.

2.7.4 Earth’s Magnetic Field As A Structure Analogous To Searl’s Machine

Earth’s magnetic field rotates and this suggests that it is also kind Searl’s machine. The frequency of rotation is one cycle per 24 hours (10 cycles per second for the Searl’s machine of [H19]). If Searl’s machine indeed involves a time reversal, one might expect that similar time reversal occurs in the case of the Earth’s magnetic field. Therefore one expects a bio-rhythm with a period of 24 hours decomposing to dissipative self-organization period and a healing period.

Wake-sleep cycle is obvious candidate for this bio-rhythm. During sleep brains and perhaps entire organism entangles with the magnetosphere to give rise to self-organizing collective magnetospheric consciousness, which is something else than a mere passive sensory representation and draws actively energy from the biosphere by buy now -let others pay mechanism by emitting negative energy MEs.

The outer magnetosphere, in particular plasma sheet corresponds to theta and delta bands for protons from the requirement that the length of ME defines an appropriate magnetic transition frequency at a given point. Theta and delta bands indeed dominate during sleep. alpha band is at the boundary between the inner and outer magnetosphere and dominates during hypnagogic states during which conscious experience involves transpersonal components.

The prediction is that EEG corresponds to negative energy photons and time reversed MEs during sleep. During daytime the inner magnetosphere is activated and in a role of passive computer monitor. Thus brain would generate during the wake-up period positive energy MEs inducing self-organization at magnetosphere and personal magnetic canvas responsible for the sensory representations. Night-day dichotomy would correspond to negative-positive energy dichotomy for MEs, and this dichotomy might be detectable from EEG (during night time coherent EEG laser beams would transform to their phase conjugates). That night side magnetosphere corresponds structurally and functionally to motor areas and frontal lobes, and day side magnetosphere to the sensory areas, was proposed already earlier in [K67]. Although this picture is bound to an over-simplification, it might be a good starting point.

The anomalous radiation associated with the Searl’s machine should correspond to a self-organization of the magnetospheric plasma by remote metabolism using the metabolic resources of the sleeping brain and body. From the point of view of biosphere this process would be a healing process since time reversals of dissipative processes occur. Magnetic transitions of superconducting charged particles (protons and electrons) are good candidates for generating anomalous ELF radiation. Negative energy EEG MEs carry high (negative) frequency MEs resulting when ions jump from magnetic flux tubes to smaller space-time sheets. In self-organizing plasma regions an entire hierarchy of space-time sheets is expected to be present, and could give rise to wide range of negative energy photons, microwave photons in particular. This vision provides a tentative model for how the highly self-organization plasma sheet at the night side of the magnetosphere uses the metabolic energy from sleeping brain to self-organize and to construct sensory representation about biosphere [F7].

Chapter 3

Bio-Systems as Conscious Holograms

3.1 Introduction

The idea about brain as hologram is very attractive but it is not easy to give precise and testable contents for this notion. This chapter is devoted to the question in what precise sense living matter can be regarded as a hologram.

3.1.1 Strong Form Of Holography

As I wrote the first version of this chapter, I did not yet know anything about strong form of holography, which is now a basic principle of quantum TGD. It states that 2-D surfaces (string world sheets and partonic 2-surfaces) with parameters characterizing them belonging to some algebraic extension of rationals allow to code the information about space-time surfaces and quantum states in zero energy ontology (ZEO) - second notion emerged later. This notion of hologram is very near to the notion of hologram used in real life and leads to TGD variant of AdS/CFT correspondence but formulated at space-time level rather than bringing in 10-D space-time. The reason for simplicity is the huge generalization of 2-D conformal invariance possible in TGD framework.

Although this notion of hologram based on strong form of holography is rather abstract, it leads to powerful basic predictions such as generalization of p-adic length scale hypothesis crucial for understanding living matter in TGD framework. Also evolution can be understood as a gradual increase of the complexity of the algebraic extension of rationals. What makes strong form of holography possible is quantum criticality implying infinite fractal hierarchy of quantum critical systems (like sphere at the top of hill at the top of ...) labelled by the value of effective Planck constant $h_{eff} = n \times h$. At classical level it means that Noether charges for a sub-algebra of super-symplectic isomorphic to it vanish classically and annihilate positive and negative energy parts of zero energy states: this huge reduction of degrees of freedom makes holography possible.

The reduction of quantum criticality increases h_{eff} and means transition to higher evolutionary level. It occurs spontaneously but means death of self: living matter is fighting to stay at criticality and uses metabolism and homeostasis as tools and in this way makes it possible for their sub-selves (mental images) to evolve re-incarnation by re-incarnation taking place in each death (state function reduction to the opposite boundary of causal diamond (CD)).

In this framework one could see physical system, in particular living system, as a collection of partonic 2-surfaces connected by strings creating correlations between them. The formation of gravitational bound states is due to the strings with large h_{eff} . Strings are accompanied by magnetic flux tubes and a very attractive hypothesis is that by stability they must carry monopole fluxes meaning that no current (analogous to that flowing in inductance coil) is needed to create the magnetic fields involved. Magnetic body consisting of magnetic flux quanta/tubes carrying dark matter is indeed the key player in TGD inspired model of living matter: it serves as intentional agent receiving sensory data from biology body and uses it as motor instrument. EEG and its generalizations serve as control communication tool of magnetic body.

3.1.2 The Notion Of Conscious Hologram

At the level of quantum TGD the notion of quantum gravitational holography emerges naturally in the sense that 3-surfaces code for data about pieces of 4-surfaces just like 2-dimensional hologram plates codes data about a 3-dimensional image. Strong form of Equivalence Principle stating that light-like 3-surfaces defining parton orbits and space-like surface at the ends of causal diamond define equivalent representations implies strong form of holography already explained.

Classical non-determinism of the basic variational principle however implies that TGD based physics does not reduce to the moment of big bang. Massless extremals which are topological counterparts of light rays in TGD could provide a realization of this idea. Unfortunately, this notion of hologram is yet quite too abstract to be applicable to the concrete modelling of living matter.

Even more, the basic challenge is to generalize the notion of the ordinary hologram to that of a *conscious* hologram, about which bio-holograms would be examples. The notion of quantum gravitational hologram is defined at the level of geometric, purely physical existence whereas conscious holograms exist at the level of subjective existence defined by the sequence of quantum jumps and giving rise to the self hierarchy. Of course, these two notions of hologram must be closely related.

The notion of *conscious* hologram follows from the ZEO based quantum measurement theory. Consciousness is universal and all systems possess self identifiable as a sequence of state function reductions to a fixed boundary of corresponding CD. The boundaries of CD are in asymmetric position: at the passive boundary of CD the state does not change during this sequence (Zeno effect) whereas at the active boundary the members of state pairs are not reduced but only localized to fixed moduli in the space of moduli of CD after each unitary time evolution meaning dispersion in the moduli space of CD [K77]. The moduli correspond to the size scale of CD and to the discrete Lorentz boosts acting on the active boundary and leaving the passive boundary invariant. Somewhat loosely one might say that by strong form of holography selves correspond to string world sheets and partonic 2-surfaces defining the holograms. Negentropic entanglement (NE) is the essence of consciousness and binds smaller selves to large ones. In particular, in many-sheeted space-time sub-selves representing mental images can entangle although selves remain un-entangled. Magnetic flux tubes connecting corresponding sub-systems (partonic 2-surfaces) serve as space-time correlates for the negentropic entanglement.

At space-time level the notion of conscious hologram requires the topological field quantization. Classical fields and matter form a Feynman diagram like structure consisting of lines representing matter (say charged particles) and bosons (say photons). The matter lines are replaced by space-time sheets representing matter (elementary particles, atoms, molecules,...), and virtual bosons are replaced by topological light rays (“massless extremals”, MEs). Also magnetic flux tubes appear and together with MEs they serve as correlates for bound state quantum entanglement.

The classical fields associated with MEs interfere only at the nodes, where they meet, and one has a hologram like structure with nodes interpreted as the points of a hologram. Thus one avoids the loss of information caused by the interference of all signals everywhere. This aspect is crucial for understanding the role of em fields in living matter and brain. The MEs corresponding to “real photons” are like laser beams entering the hologram and possibly reflected from it. What is new that the nodes can be connected by “virtual photon” MEs also analogous to laser beams. Hence also “self-holograms” with no laser beam from external world are possible (brain without sensory input).

The hologram has a fractal structure: there are space-time sheets at space-time sheets and high frequency MEs propagating effectively as massless particles inside low frequency MEs serving as quantum entangling bridges of even astrophysical length. The particle like high frequency MEs induce “bridges” between magnetic flux tubes and atomic space-time sheets at the receiving end. This makes possible the leakage of supra currents from magnetic flux tubes to atomic space-time sheets analogous to the exposure of film producing hologram. The leakage induces dissipation, self-organization, and primitive metabolism as a cyclic flow of ionic currents between the two space-time sheets, and thus a Darwinian selection of the self-organization patterns results. Under certain conditions the leakage followed by dropping back to the larger space-time sheet can also give rise to a many-sheeted laser. The low frequency MEs are responsible for the bound state

entanglement, macroscopic quantum coherence and co-operation whereas high frequency MEs are responsible for self-organization and competition.

The 3-D vision associated with ordinary holograms generalizes to stereo consciousness resulting in the fusion of mental images associated with the points of conscious hologram.

3.1.3 Time Mirror Mechanism

Time mirror mechanism involves analog for a reflection of laser beam but in time direction. The negative energy phase conjugate photons from geometric future are time reflected as positive energy photons to the direction of geometric future. These photons could be also dark photons, or more generally, dark electro-weak gauge bosons, gluons, or even gravitons. The large values of \hbar make possible time mirror mechanism in arbitrarily long time and length scales since photon energies can be above thermal energy for arbitrarily low frequencies.

Time reflection provides a mechanism of long term memory as communications with the geometric past and a mechanism of metabolism in the case that the system of the geometric past is population reversed laser. The proposed mechanism of intentional action relies on time mirror mechanism. Dark matter hierarchy makes possible remote mental interactions in arbitrarily long time and length scales. The control of the biological body by the magnetic body (there is actually a hierarchy of them) provides the basic everyday example of remote mental interaction. The strange time delays of consciousness discovered by Libet can be interpreted as being due to the communications between biological and magnetic body.

In ZEO based quantum measurement theory negative energy signal to geometric past is generated as the first reduction to the opposite boundary of CD occurs and self transforms to its time reversal. Positive energy reflected signal to future is generated and received consciously as the time reversed self dies and original self is re-created.

3.1.4 Biophotons

The general vision developed in [K44] - developed before strong form of holography and ZEO - suggests how bio-systems could generate holograms in much more concrete sense than the wetty and hot and noisy character of this environment would suggest: even mechanisms generating analogs of laser beams could be there. Bio-photons are excellent candidates for the coherent light generated in living matter. An alternative identification is as de-coherence products of dark photons generated by living matter.

The findings of Peter Gariaev and collaborators [I85] provide a new support for the notion of many-sheeted DNA. The findings also lead to a concrete model for how bio-photons affect many-sheeted DNA, and in this way induce a generation of coherent radio waves and ELF waves. Moreover, a concrete model for how bio-systems act as many-sheeted lasers at various wavelengths emerges.

It has turned out that bio-photons [K17] can be identified as ordinary photons resulting in the transformation of $h_{eff} = n \times h$ dark cyclotron photons with energies proportional to $\hbar_{eff}eB/m$ to ordinary photons and that biophoton energy spectrum - in the energy range including visible and UV photons and characterizing biomolecules - is universal if h_{eff} is proportional to the mass of the charged particle. This is true if the condition $h_{eff} = h_{gr} = GMm/v_0$, where v_0 is velocity parameter - some characteristic velocity for the system consisting of masses M and m . M corresponds to dark mass and need not thus include visible mass. m can be any elementary particle or even atom or biomolecule. It is not actually clear how large m can be. What is important is that gravitational Compton length does not depend on particle mass m : this is in accordance with Equivalence Principle (EP) and means simultaneous gravitational quantum coherence for all particles. This suggests that gravitation plays fundamental role in living matter.

3.1.5 The Work Of William Tiller

William Tiller in Stanford University has carried out impressive experimental work with what he calls intention imprinted electronic devices (IIED), and his results challenge that standard assumption that the intentions of experimenter do not affect the experimental apparatus [J123, J119, J120]. The analysis of the work of Tiller in the conceptual framework of TGD leads to

the proposal that four-wave interaction, which is a basic mechanism to produce phase conjugate waves (negative energy topological light rays), could serve also as a basic mechanism of intentional action. When the two oppositely reference beams have slightly different frequencies. A first principle explanation for the scaling law of homeopathy, which involves a pair of high and low frequencies and an excitation moving with a sub-luminal velocity, emerges.

Note that the pair of high and low frequencies would naturally correspond in TGD framework to ordinary and dark photon. In this case both excitations could be photons. This would give connection also to bio-photons. The transformation of dark photon to ordinary photon would be the mechanism behind the scaling law.

Time mirror mechanism involving probe wave and its phase conjugate are needed to get the energy to build this kind of hologram. The archetypal holograms defined by the standing waves resulting as interference patterns of reference waves moving in opposite directions can be regarded as basic building blocks for the symbolic representations of sensory data. Nerve pulse patterns reflect the basic aspects underlying four-wave interactions. Pairs of ELF and microwave frequencies are necessary in order to have moving standing wave patterns serving as correlates for the neuronal synchrony: hence one can understand the role of EEG and kHz oscillations. Rate coding results from the possibility to choose the frequency of the microwaves responsible for the hologram. Also Ca_{++} waves and other ionic waves should define archetypal symbolic representations of the sensory data.

The notion of hologram generalizes. The quintessence of standing waves is that they correspond to synchronous coherent oscillations of the entire system. Ionic plasma oscillations occur with the same frequency irrespective of the wave vector and thus they define ideal holograms in the sense that the same pattern occurs repeatedly. Ordinary matter is completely Z^0 ionized and therefore Z^0 plasma frequencies are ideal for generating living holograms. As a matter fact, the observation that Z^0 plasma frequency of water corresponds to energy .44 eV, the basic metabolic energy currency, put the bell ringing. Various biologically important ions define also plasma frequencies. p-Adic length scale hypothesis predicts entire hierarchy of plasma frequencies coming as powers of $2^{3k/4}$. Thus the prediction about hierarchy of holograms is readily testable.

In the sequel the basic ideas of the many-sheeted quantum control are summarized, the notion of conscious hologram is introduced, phase conjugation and time mirror mechanism is discussed, a concrete model for bio-photons and for how living system acts as a many-sheeted laser emerging from the experimental findings of Peter Gariaev and his group [I82] is described, and the application to remote mental interactions and various tests of the concept are discussed at the general level. The chapter ends with the detailed model for the findings of William A. Tiller and vision about how four-wave interaction generalizes. The discussion is essentially that written much before ZEO, hierarchy of Planck constants and other ideas and I have added only comments to the text.

The appendix of the book gives a summary about basic concepts of TGD with illustrations. Pdf representation of same files serving as a kind of glossary can be found at <http://tgdtheory.fi/tgdglossary.pdf> [L21].

3.2 Conscious Hologram

The notion of conscious hologram gives hopes about a unified description of living matter and remote mental interactions.

3.2.1 What Are The Basic Properties Of Conscious Hologram?

To proceed it is good to ask what are the basic features of ordinary holograms possessed also by conscious holograms.

Distributed information storage

The most fundamental and biologically attractive property of hologram is the distributed character of the information storage in the sense that a small piece of hologram represents satisfactorily the same image as entire hologram. This makes information storage very robust. This condition is very general and is satisfied by the neurons of cortex which receive information from a large number

of neurons, and it would seem that neurons are good candidates for points of a 3-D conscious hologram. The fractality of the TGD universe allows an entire hierarchy of hologram structures corresponding to the hierarchies of space-time sheets and of selves.

Continuity

The neighboring points of the hologram store almost the same information. Also in the case of a primitive organisms like salamanders each neuron of brain seems to represent almost the same information (even when salamander's brain is shuffled like a pack of cards, salamander recovers and preserves its memories [J109]). This would suggest that single neuron forms a hologrammic image about a considerable part of brain. This could apply at the level of any cell and body parts to which it belongs.

The assumption that cells are like points of hologram plate would explain why cell replication is the basic architectonic principle in the living matter. Quite generally, the structures which appear as almost identical copies, say proteins, DNA triplets, cell nuclei, cells, and the millimeter sized information processing units in cortex, are good candidates for "points" of a conscious hologram. The TGD based view about higher levels of the self hierarchy suggests that even individual organisms of a given species correspond to the points of conscious holograms representing higher multi-brained conscious entities. Also various body organs, brains, substructures of brain, ..., and even the DNAs of a given species could form similar collective conscious entities.

3.2.2 Stereo Consciousness And The Notion Of Conscious Hologram

Ordinary holograms are 3-dimensional. This is made possible by the preservation of the phase information achieved by the interference between reference beam and the beam scattered from the object. On the other hand, ordinary stereo vision results somehow from two slightly different views about the same visual field provided by the retinas. In TGD inspired theory of consciousness stereo-consciousness results, when different sub-selves bound-state entangle to single sub-self: each sub-self gives rise to a view about (possibly) the same object of perceptive field. The entanglement of right and left visual fields so that separate visual fields fuse to single 3-D visual field is a special case of this. When the sensory fields are too different, stereo consciousness is not sensible. In this kind of situation sensory rivalry results so that either left or right hemisphere determines the conscious-to-us percept. This is analogous to the "alike likes alike" rule of Sheldrake [?] characterizing morphic resonance. In particular, during sleep a large number of sufficiently similar brains could quantum entangle to give a stereo view about "human condition".

The question is whether the hologram mechanism understood in a sufficiently abstract sense could be consistent with the generation of stereo consciousness by bound-state entanglement. This seems to be the case. The entangling systems would correspond to the points of a conscious hologram, neurons, cells or some other structures. The survival value provided by stereo consciousness explains why populations of almost similar living systems have resulted in evolution. The geometric correlate for the bound state entanglement is the formation of flux tubes, say magnetic flux tubes and MEs. These flux tubes imply classical coherence necessary for the hologram property in the ordinary sense, as well as macroscopic and macro-temporal quantum coherence in the time scale defined by the lifetime of the bound state.

MEs are TGD counterparts of topological light rays and the classical fields propagating along them are natural candidates for generating self-hologram as a system which defines its own hologrammic image. This requires that a given basic unit is connected by join along boundaries bonds to a large number of other units and receives classical information from and quantum entangles with them in the hologrammic state. When bound state quantum entanglement is not present, system is in a "reductionistic mode" and decomposes into separate sub-selves. Classically this corresponds to the de-coherence of the classical fields associated with the units and absence flux tubes connecting the units of the conscious hologram.

The experimental findings of Russian researchers about bio-holograms [?] support the notion of conscious hologram. Kirlian images taken from say fingertips are studied. What is found is that the simultaneous electrical stimulation of some body part, say inner ear, affects the spectrum of visible light in the Kirlian image of the finger tip. Even more, it is possible to abstract the image of the stimulated body part from the pattern of the visible light in Kirlian image.

3.2.3 Questions

At least the proposed basic aspects seem to be worth of taking into account in an attempt to generalize the notion of hologram to that of self-hologram or conscious hologram. Several questions however remain to be answered.

How is it possible to abstract any conscious information at all from the self-hologram?

Ordinary hologram is completely diffuse and does not contain visual information as such and reference beam is needed to generate the 3-dimensional picture. In case of a self-hologram this mechanism need not work, since even the notion of reference beam is questionable. In the case of an ideal self-hologram every part of the hologram receives fields from all the other parts and there are actually large number of fields interfering at a given point of the hologram. There are two ways to circumvent the problem: hologram is not ideal and there is a symmetry breaking input from external world.

1. Self-holograms are somewhere between ordinary photo and ideal hologram

Self-hologram is not ideal one: not every unit is connected with every other unit and self-hologram is expected to be somewhere between the ordinary photo and ideal hologram. A given block of units receives information about some other blocks of units and forms a hologram about the field patterns sent by those blocks. For instance, these blocks could correspond to cortical features associated with a given sensory modality and firing synchronously. Topologically this means that these blocks of units are connected by a large number join along boundaries bonds/flux tubes whereas the number of flux tubes to the other units is relatively small. Thalamo-cortical and cortico-thalamic connections provide a basic example of this. Topographical connections from sensory organs to thalamus and from thalamus to the primary sensory areas correspond to the geometric optics limit in which interference effects are minimized. Diffuse connections from brain stem responsible for controlling general alertness correspond to the second extreme.

2. Breaking of symmetry by inputs from external world

Self-hologram receives input from the external world via what might be called primary sensory organs (in generalized sense). This information is shared holographically by flux tubes connecting the primary sensory organs to other units. This breaks the symmetry between units even in the case that ideal self-hologram is in question. When some unit receives strong stimulation and self-organizes vigorously, it also sends much stronger stimuli to the other units. Hence the contribution of this unit to the experiences of other units can dominate and other units tend to experience the same experience as the strongly stimulated unit.

For instance, in the case of bio-holography [?] by Kirlian imaging the electrical stimulation of the inner ear implies that the input from the inner ear to the finger tip starts to dominate over the input from the other body parts. This picture conforms with the general facts about conscious experience. When the sensory input breaking the symmetry is absent as in case of a deep meditative state, a holistic state of one-ness in which mind is “empty” results. On the other hand, when a highly emotional mental image is present, this mental image dominates over the other mental images. The emotional content of the mental image obviously measures how strongly it contributes to the self-hologram. The fact that information molecules responsible for emotions are scattered around the entire body, encourages to think that it is indeed the entire body which experiences emotions, and that limbic brain is more like a primary emotional organ. Emotional expression would result from the quantum communication of emotions from the limbic brain to the body which now takes the same role as brain in case of sensory input.

3. In what sense mental functions are localized?

This picture is consistent with the finding that the localization of mental functions to various parts of brain seems to make sense. As already noticed, one can divide the units of the self-hologram into two classes: those which receive primary stimulus, and those which receive only secondary stimuli. This division can be made at several levels. Primary sensory organs viz. other parts of CNS, thalamus viz. cortex, primary sensory areas viz. higher sensory areas are examples of divisions of this kind. The possibility of this kind of division means that the assumption about the localization of consciousness to brain and various mental functions to various parts of brain,

although basically wrong, defines a reasonable “as-if” theory. The units which receive the primary stimuli replace functional units in the hologrammic view about brain. Artificial stimulation of, say, cortical neurons can artificially make them the primary sensory organs and the fact that this kind of stimulation can induce memories and complex hallucinations, suggests that these neurons indeed have complex conscious experiences differing from our experiences only in that the stereo consciousness aspect is not present.

What physical process corresponds to the formation of a conscious hologram?

Ordinary hologram plate results, when the reference beam and the beam scattered from an object interfere and induce a local change in the transparency of the film. This change is proportional to the local intensity of the incoming light. In the case of a self-hologram the reference beam and the light scattered from the object are replaced by the interference of the classical radiation fields propagating along MEs and converging to a given unit like light rays to retina. Hologram results locally if one assumes that the classical radiation resulting in the interference induces some physical change proportional to the net intensity of the classical radiation field, and provided that the units are connected by flux tubes to form a macroscopic quantum bound state.

Conscious experience involves a formation of self-organizing mental images. A very general mechanism inducing self-organization is the leakage of ions from the super-conducting magnetic flux tubes to the atomic space-time sheets, where the ions dissipate their energy, and end back to the magnetic flux tubes sooner or later. In case of protons this process corresponds to the fundamental step in the metabolic ADP-ATP cycle. Very probably the process occurs for other ions and perhaps even for molecules, and in this generates EEG waves by the mechanism proposed in [K62].

This process occurs only if “bridges” between atomic space-time sheets and magnetic flux tubes are somehow created. If the number of bridges formed is proportional to the total intensity of the classical radiation entering into the unit along various topological light rays converging to it, a hologram like structure results.

A concrete interpretation for this mechanism is suggested by various findings related to the role of microwaves in living matter. Microwaves with energies of quanta not too much above the gap energy of bio-super-conductor, generate “bridges” between magnetic flux tubes and atomic space-time sheets inducing the breaking of super-conductivity and local self-organization. This mechanism gives rise to the many-sheeted ionic flow equilibrium defining dynamical control circuitry taking care of quantum homeostasis. The scaling law of homeopathy leads to the view that ELF MEs serve as quantum entanglers, em bridges connecting units of a conscious hologram, and that microwave MEs propagate along them like mass-less particles along ELF MEs, and induce self-organization at the receiving end. The interference of the classical fields associated with microwave MEs in the region with size considerably smaller than wavelength to guarantee effective point-likeness would give rise to single point of the hologram.

Both the fractality of TGD Universe and the findings of bio-holography [?] suggest that the mechanism is much more general. Also MEs with lengths in wavelength range of visible light and radio frequency (RF) MEs in kHz range define low-high frequency pairs of MEs. The electric voltage associated with say finger tip and oscillating at about kHz frequency defines the RF ME to which RF MEs from various body parts converge and fuse with. Along RF MEs propagate the visible MEs with lengths coming as multiples of the wave lengths of visible light. The interference occurs in a region of size smaller than wavelength of visible light. When some body part is stimulated electrically, it emits a large number of visible MEs ending down to the fingertip and contributing to the Kirlian image.

As noticed, the sizes of the basic hologrammic units corresponding to a given wavelength must be smaller than the wavelength to guarantee effective point-likeness. The experiments of Gariaev [I85] demonstrate that the illumination of DNA with a visible laser light generates radio waves with frequencies up to MHz with frequencies in kHz range having especially strong intensities, which suggest that the wavelength range associated with the visible light corresponds to sub-cellular structures, DNA being the most natural candidate in this respect. Also the findings about bio-holograms [?], and the fact that kHz frequency corresponds to the duration of nerve pulse and to the frequency of neuronal synchrony support this identification. The units associated with microwave MEs must have sizes in the length scale range 1 mm-300 mm and millimeter sized structures in

cortex (cortex has thickness of order millimeter).

Also larger structures of cortex are candidates for hologrammic units at the level of multi-brained collective consciousness. Magnetospheric sensory representations would naturally correspond to this kind of multi-brained conscious holograms and various parts of brain and also body parts could give rise to what might be regarded as a species consisting of individuals and possessing collective consciousness. Scaling law makes this hypothesis quantitative and assigns to a structure with a given size an ELF frequency responsible for the entanglement with magnetosphere.

What about the notions of reference beam and static hologram?

The view about holograms as generated by a simple reference beam and the beam representing information is too simplistic to be applied as such to conscious hologram. For instance, the number of interfering beams is large since each ME converging to given unit of self-hologram corresponds to a particular beam. However, in a situation in which single ME gives a dominating contribution, the remaining MEs collectively interfere to what might be regarded as a counterpart for a slowly varying reference beam.

Under certain conditions it is also possible to talk about quasi-static conscious hologram. There are two time scales involved: the lifetime τ_B of the macroscopic bound state defined by the hologram, and the lifetime τ_s of the “bridges” connecting atomic space-time sheets and larger space-time sheets. If these time scales are longer than the duration of the stimulation from the active units of hologram, quasi-static hologram results. At the level of conscious experience the reference beam could be interpreted as the background whereas the dominating contribution to conscious experience would correspond to the figure.

p-Adic length scale hierarchy suggests the presence of a hierarchy of time scales corresponding to the lifetimes of these bridges, and synaptic strengths might be seen as quasi-static conscious holograms resulting in this manner. If this is the case, the breaking of super conductivity and dissipation should be a crucial element of synaptic activity. The fact that the dendrites are responsible for most ohmic losses in the neural circuitry [E3] conforms with the idea that the breaking of super-conductivity occurs dominantly in the dendrites. The age hierarchy for quasi-static holograms would correspond to a hierarchy of supra current leakages occurring from various space-time sheets labelled by p-adic primes. The effect of various neural transmitters and information molecules might be understood as a generation of bridges between space-time sheets characterized by the duration of the effect. The more lasting the effect is, the larger the corresponding space-time sheet would be. This conforms with the fact that information molecules with long lasting effect are responsible for emotions and moods, which are indeed whole-body effects.

How to avoid the problems caused by finite temperature?

The basic objection against the notion of conscious hologram is that thermal fluctuations destroy the quantum coherence for sub-thermal photon (boson) energies. In the standard physics framework this would have fatal consequences.

Before the realization that Planck constant is most naturally dynamical and quantized in TGD Universe [K141, K43], the hypothesis was that the sheets of many-sheeted space-time are thermally isolated in a good approximation so that the temperatures of large space-time sheets can remain very low for long periods of time. This would allow to circumvent the thermal constraint. A more elegant solution working also for the isothermal case is that large space-time sheets correspond to large values of Planck constant implying that for any given frequency there exist infinite number of levels in dark matter hierarchy such that photon energy is above thermal energy. Dark matter hierarchy would therefore make universe quite literally a conscious hologram.

The stimulus leading to the ideas about dark matter hierarchy and large \hbar came from the observations suggesting that gravitationally bound states of dark matter correspond to a gigantic value of Planck constant [K111, K43], [E2]. This suggests that also dark gravitons are there and make universe a hologram in astrophysical and cosmological length scales. These ideas lead to a precise proposal for how the hierarchy of Planck constant is realized in terms of the book like structure of generalized embedding space as well as to a proposal for a spectrum of Planck constants [K47].

TGD inspired quantum biology and number theoretical considerations suggest preferred values for $r = \hbar/\hbar_0$. For the most general option the values of \hbar are products and ratios of two integers n_a and n_b . Ruler and compass integers defined by the products of distinct Fermat primes and power of two are number theoretically favored values for these integers because the phases $\exp(i2\pi/n_i)$, $i \in \{a, b\}$, in this case are number theoretically very simple and should have emerged first in the number theoretical evolution via algebraic extensions of p-adics and of rationals. p-Adic length scale hypothesis favors powers of two as values of r .

One can however ask whether a more precise characterization of preferred Mersennes could exist and whether there could exist a stronger correlation between hierarchies of p-adic length scales and Planck constants. Mersenne primes $M_k = 2^k - 1$, $k \in \{89, 107, 127\}$, and Gaussian Mersennes $M_{G,k} = (1+i)^k - 1$, $k \in \{113, 151, 157, 163, 167, 239, 241, \dots\}$ are expected to be physically highly interesting and up to $k = 127$ indeed correspond to elementary particles. The number theoretical miracle is that all the four p-adically scaled up electronic Compton length scales with $k \in \{151, 157, 163, 167\}$ are in the biologically highly interesting range 10 nm-2.5 μm). The question has been whether these define scaled up copies of electro-weak and QCD type physics with ordinary value of \hbar . The proposal that this is the case and that these physics are in a well-defined sense induced by the dark scaled up variants of corresponding lower level physics leads to a prediction for the preferred values of $r = 2^{k_d}$, $k_d = k_i - k_j$.

This proposal will be referred to as Mersenne hypothesis and it leads to strong predictions about EEG since it predicts a spectrum of preferred Josephson frequencies for a given value of membrane potential and also assigns to given value of \hbar a fixed size scale having interpretations as size scale of body part or magnetic body.

3.2.4 Self-Referentiality And Space-Time Topology

The notion of self-referentiality is one of the deepest and most fascinating notions of mathematics but for some reason it has not caught the full attention of physicists. I encountered the mystic variant of this notion during my “great experience” (the idea about living system as a computer sitting at its own terminal) and a more mathematical variant of the idea for a year or two later while reading the book “Gödel, Escher, Bach” of Douglas Hofstadter. It took however more than fifteen years before I managed to identify a possible concrete realization of the notion in TGD based physics. Although topological self-referentiality is only loosely related to the notion of conscious hologram, it deserves to be discussed here.

Does physical system provide a representation for a theory about physical system?

MEs and magnetic mirrors play a key role in TGD based model of living matter. The connection with standard chemistry has been however lacking. It seems that some deep principle is needed to build this connection. The hints about the big principle come from the following observations related to the topological field quantization implying what might be called Bohr orbitology for the classical fields.

1. TGD predicts the existence of negative energy space-time sheets, in particular MEs. The prediction is based solely on the assumption that the space-time is representable as a 4-surface.
2. One can understand gravitational binding energy only if negative energy MEs represent this energy. This suggests that binding energy of a system has a very concrete representation as a negative energy MEs.
3. Quantum entanglement has as a geometric correlate join along boundaries bonds, in particular MEs and possibly also magnetic mirrors. Only the entanglement associated with the bound states is stable against the state preparation process leading to a maximally unentangled state in each quantum jump.
4. Classical superposition for em fields could mimic quantum superposition for states. The multiples of the fundamental frequency for ME could represent the BE condensate of bosons with energy defined by the fundamental frequency $f = c/L$.

5. The phase increments of the CP_2 coordinates around closed loops could represent phase increments of spinor fields and super-conducting order parameters around them as suggested in [K64].
6. flux tubes can represent even half-odd integer spin topologically. The flux tubes connecting 3-surface to a larger 3-surface get entangled in 2π rotation but in 4π rotation no entanglement results: this is due to the fact that the bonds provide a representation for the homeotopy group of 3-dimensional rotation group. A good manner to visualize the situation is to think of a cube inside a larger cube with threads connecting the corresponding vertices of the cubes. An interesting question is whether also spin and statistics connection could be represented classically somehow.
7. Dark matter hierarchy would make possible the concrete realization of self-referentiality. The fact that for a given energy the size of the space-time sheet scales as \hbar suggests a hierarchical structure for self representations in the sense that given level of dark matter hierarchy provides representations of lower levels. These representations would be abstractions, space-time averages with too small details smoothed out. This is just what our brains in general and theory builders in particular are doing all the time. What is new that Nature itself would be constructing these idealizations so that the idealizations of reality provided by various levels of dark matter hierarchy would be an essential element of reality.

These observations suggest a far-reaching generalization. Perhaps many-sheeted space-time allows the system to represent in its own structure the theory about itself. All theoretical concepts usually thought to have rather ethereal existence would have a concrete topological representation. These representations would exist already at the elementary particle level. Not only bio-molecules, but even hadrons, would be accompanied by a topological representation about their theory analogous to a written language. Thus not only cognition but also symbolic representations of thoughts would be present in all length scales. The adelic view about space-time involving both real and p-adic space-time sheets for various p-adic number fields and forming the analog of book realizes this vision mathematically.

This idea of self-referentiality is actually an essential part of the basic philosophy of TGD. TGD inspired theory of consciousness implies that the Cartesian division to a world and theory about it is an illusion. Quantum histories, which are TGD counterparts for the solutions of field equations *are* the reality, there is no need to postulate any “real” reality behind them since conscious experience is associated between quantum jumps between quantum histories rather than the “real” reality. “Ontogeny recapitulates phylogeny” principle states that quantum histories have geometric and topological correlates at space-time level. This is just what the idea about topological representation of a theory about the system as a part of the system itself means. System could consist of a hierarchy of levels such that $N + 1$: th level represents N : th level. Or perhaps more precisely, what results in the interaction of N : th level systems.

If one accepts the idea that real and p-adic space-time regions are correlates for matter and cognitive mind, one encounters the question how matter and mind interact. The original candidate for this interaction was as a phase transition leading to a transformation of the real space-time regions to p-adic ones and vice versa. These transformations would take place in quantum jumps. p-Adic-to-real phase transition would have interpretation as a transformation of thought into a sensory experience (dream or hallucination) or to an action. The reverse phase transition might relate to the transformation of the sensory experience to cognition. Sensory experiences could be also transformed to cognition by initial values realized as common rational points of a real space-time sheet representing sensory input and a p-adic space-time sheet representing the cognitive output. In this case the cognitive mental image is unique only in case that p-adic pseudo constants are ordinary constants.

It turned out that this interpretation leads to grave mathematical difficulties: one should construct U-matrix and M-matrix for transitions between different number fields, and this makes sense only if all the parameters involved are rational or algebraic. This however means reduction to an algebraic extension of rationals.

A more realistic view is based on the idea that p-adic space-time sheets indeed define a theory about real space-time sheets. The interaction between real and p-adic number fields would mean that p-adic space-time surfaces define cognitive representations of real space-time surfaces

(preferred extremals). One could also say that real space-time surface represents sensory aspects of conscious experience and p-adic space-time surfaces its cognitive aspects. Both real and p-adics rather than real or p-adics.

Strong form of holography implied by strong form of General Coordinate Invariance leads to the suggestion that partonic 2-surfaces and string world sheets at which the induced spinor fields are localized in order to have a well-defined em charge (this is only one of the reasons) and having having discrete set as intersection points with partonic 2-surfaces define what might be called “space-time genes”. Space-time surfaces would be obtained as preferred extremals satisfying certain boundary conditions at string world sheets. Space-time surfaces are defined only modulo transformations of super-symplectic algebra defining its sub-algebra and acting as conformal gauge transformations so that one can talk about conformal gauge equivalences classes of space-time surfaces.

The map assigning to real space-time surface a cognitive representation would be replaced by a correspondence assigning to the string world sheets preferred extremals of Kähler action in various number fields: string world sheets would be indeed like genes. String world sheets would be in the intersection of realities and p-adicities in the sense that the parameters characterizing them would be algebraic numbers associated with the algebraic extension of p-adic numbers in question. It is not clear whether the preferred extremal is possible for all p-adic primes but this would fit nicely with the vision that elementary particles are characterized by p-adic primes. It could be also that the classical non-determinism of Kähler action responsible for the conformal gauge symmetry corresponds to p-adic non-determinism for some particular prime so that the cognitive map is especially good for this prime.

Real and p-adic space-time sheets would have common “space-time genes”. This implies that p-adic space-time sheets define a cognitive representation of real ones and real space-time sheets a sensory representation of p-adic ones. In atomic and molecular physics the basic implications would be following.

1. Atoms and bio-molecules would carry a representation about their own theory based on MEs. Since MEs carry light like four-momentum, they should appear as pairs of parallel MEs with opposite momenta and with frequency corresponding to one half of the binding energy: $f = E_B/2$. The frequencies associated with ME come as multiplies of its fundamental frequency $f = c/L$, L the length of ME. This dictates to a high degree the lengths of the MEs associated with a given binding energy. The most natural length corresponds to the wave length defined by one half of the binding energy. In the spirit of Bohr orbitology justified by the allowing only preferred extremals of Kähler action with the property that there exists infinite number of deformations with a vanishing second variation probably representing conformal symmetries, one can also require that ME pair has a classical energy equal to the binding energy: this requirement correlates the field strength and the thickness of the negative energy MEs.
2. Atomic binding energies would correspond to MEs with wave lengths in UV region. The binding energies of typical covalent bonds would give rise to MEs with lengths in wave length region which corresponds to UV and visible light. The binding energies of hydrogen bonds in turn would give rise to MEs with lengths which correspond to wave lengths in the near infrared, cell size would be the typical length scale.
3. In the case of a potential well, such as the one associated with a harmonic oscillator or constant magnetic field, a natural representation would be in terms of positive energy ME allowing various harmonics. Vibrational and rotational frequencies would correspond to infrared and micro-wave region and magnetic energies to ELF region. The idea that these frequencies correspond to high level representations for the system is of course already now a basic element of TGD inspired theory of consciousness and conforms fully with the idea about topological self reference.

Possible biological implications of topological self reference

The notion of topological self-referentiality, if correct, means the possibility to combine enormous amount of knowledge from biochemistry to build a concrete view about em bodies of molecules and

about how living matter represents itself in its own structure. One could also try to identify the chemical counterparts for the special frequencies predicted by the p-adic length scale hypothesis. One might even hope that one could at some level understand how such very high level phenomena like written language emerge from the topological self-referentiality. What is so interesting is that the hypothesis connects various length scales. For instance, the binding energies of atoms with nuclear charges $Z \sim 10$ are in keV range and correspond to MEs with size of order nanometer. Perhaps even the structure of condensed matter is partly coded into the representation of the binding energies of atoms.

Some examples of the possible consequences in biological length scales deserve to be mentioned.

1. The many-sheeted structure associated with a molecule would provide a representation for the molecule identifiable as its electromagnetic signature introduced in the theories of homeopathy and water memory. And not only this: this structure would also serve as a 4-D dynamical hologram serving as a photograph-like template for the self-organization of matter around the molecule. This would mean effective reductionism, but obviously only effective.
2. Genetic code would be a highly developed form of this representation. It would involve the negative energy MEs associated with various atomic and molecular binding energies. Especially important negative energy MEs would be in the visible region and associated with the covalent bonds and in the near infrared associated with the hydrogen bonds connecting DNA nucleotides together. Also the MEs associated with rotational and vibrational degrees of freedom are expected to be very important and for them liquid crystal blocks of water could serve as mimickers and amplifiers. The transparency of water to visible frequencies (covalent bonds have energies 4.7 eV in UV region) means that water is an ideal medium in the visible region for communications by MEs since coherent visible light can propagate long distances with attenuation caused only by the absorption by bio-molecules.

This picture gives a justification for the suggestion of Peter Gariaev that DNA is accompanied by laser mirror pairs [I82]. The negative energy ME pairs associated with various binding energies would correspond to the laser mirror pairs. This picture differs slightly from the earlier proposal for the realization of genetic code involving orthogonal pairs of MEs associated with each nucleotide giving rise to 4 different pairs of polarizations and suggests a simpler realization in which the four polarization pairs associated with a pair of parallel MEs would realize the genetic code in a given length scale.

Topological self-referentiality allows also to understand what happens in over-unity energy production and these insights might be also crucial for the understanding of how life has evolved as a parallel development of macroscopic quantum bound states and the ability to metabolize. The components of the system can bind mutually or with the environment and negative energy space-time sheets represent binding energy. Bound state energy is liberated as a usable energy. The resulting bound states have entanglement irreducible under state function preparation process: this makes possible fusion of sub-selves to larger sub-selves. The bound states correspond to space-time sheets having typical sizes given by the p-adic length scale hypothesis and the process means basically space-time engineering. The typical wave length of the radiation emitted in the process gives estimate for the electromagnetic or gravitational size of the bound state. In ELF frequency range the electromagnetic size is of order Earth size.

Electrolytic processes are especially interesting from the point of view of over-unity energy production. For instance, the production of hydrogen molecules in the electrolysis of water might be accompanied by the formation of large bound states of water molecules and the liberation of the binding energy as a usable energy. The signature for the process is simple: the energy liberated is larger than the energy deduced from the binding energies of water and hydrogen molecules. Rather interestingly, the hydrogen bond energy deduced from the evaporation energy per water molecule is .485 eV and is very near to the photon energy $E(167) = .4844$ eV corresponding to p-adic length scale $L_e(167) = 256L_e(151)$ for $L_e(151) = \sqrt{5}L(151) = 10$ nm: $k = 167$ defines one of the four subsequent p-adic length scales $k = 151, 157, 163, 167$ assignable to Gaussian Mersennes.

Biology provides an important area of applications and as already found the model of biophotons leads to a concrete model for the generation of pairs of positive and negative energy MEs at DNA level. Bio-molecules and cells are indeed bound states of macroscopic size. The first

form of life evolved under conditions in which electrolytic processes occurred: perhaps bound state formation led to the generation of bio-molecules and cells. What is nice that the development of long range order (negative energy MEs) would have been automatically accompanied by the development of metabolism (positive energy MEs!).

Sol-gel transition crucial for the cellular locomotion is a particular example of this process. Thus a natural path to follow in the attempts to build new energy technologies is to try to mimic what living nature has already achieved. This kind of energy production would be also wasteless and support evolution. Quantum spin glass analogy means that Kähler action has an enormous almost ground state degeneracy and only classical gravitational energy differentiates between different ground states. Thus the classical gravitational binding and also the generation of coherent gravitons by MEs might have a role to play in the quantum physics of living matter. A rough order of magnitude estimate for the gravitational binding energy for a blob of water having size $L_e(k)$ is

$$E_{gr} \sim \frac{GM^2}{L_e(k)} = G\rho^2 L_e(k)^5 \sim \frac{Gm_p^2}{L_e(137)} \frac{L_e(k)}{L_e(137)^5} \simeq 2^{-127} 2^{5/2(k-137)} \frac{1}{L_e(137)} .$$

Gravitational binding energy is larger than the p-adic energy $\pi/L_e(k)$ for $L_e(k = 179) \simeq .169$ mm. In the range $L_e(163) = 640$ nm and $L_e(167) = 2.56 \mu m$ gravitational binding frequency varies between 1 Hz and 1 kHz, that is over EEG range up to the maximal frequency of nerve pulses. For $k = 157$ and $k = 151$ the gravitational binding frequency corresponds to a time scale of 9 hours and 100 years respectively so that the time scales relevant for life are spanned by the Gaussian Mersennes. Perhaps gravitonic MEs carrying vanishing em fields accompany the basic building blocks of the cell. Neither the connection with EEG is excluded.

3.2.5 Comparison Of Maxwellian And TGD Views About Classical Gauge Fields

In TGD Universe gauge fields are replaced with topological field quanta. Examples are topological light rays, magnetic flux tubes and sheets, and electric flux quanta carrying both magnetic and electric fields. Flux quanta form a fractal hierarchy in the sense that there are flux quanta inside flux quanta. It is natural to assume quantization of Kähler magnetic flux. Braiding and reconnection are basic topological operations for flux quanta.

One important example is the description of non-perturbative aspects of strong interactions in terms of reconnection of color magnetic flux quanta carrying magnetic monopole fluxes [K53, K74]. These objects are string like structures and one can indeed assign to them string world sheets. The transitions in which the thickness of flux tube increases so that flux conservation implies that part of magnetic energy is liberated unless the length of the flux quantum increases, are central in TGD inspired cosmology and astrophysics. The magnetic energy of flux quantum is interpreted as dark energy and magnetic tension as negative “pressure” causing accelerated expansion.

This picture is beautiful and extremely general but raises challenges. How to describe interference and linear superposition for classical gauge fields in terms of topologically quantized classical fields? How the interference and superposition of Maxwellian magnetic fields is realized in the situation when magnetic fields decompose to flux quanta? How to describe simple systems such as solenoidal current generating constant magnetic field using the language of flux quanta?

Superposition of fields in terms of flux quanta

The basic question concerns the elegant description of superposition of classical fields in terms of topological field quanta. What it means that magnetic fields superpose.

1. In Maxwell’s linear theory the answer would be trivial but not now. Linear superposition holds true only inside topological light rays for signals propagating in fixed direction with light velocity and with same local polarization. The easy solution would be to say that one considers small perturbations of background space-time sheet and linearizes the theory. Linearization would apply also to induced gauge fields and metric and one would obtain linear superposition approximately. This does not look elegant. Rather, quantum classical correspondence requires the space-time counterpart for the expansion of quantum fields as

sum of modes in terms of topological field quanta. Topological field quanta should not lose their identity in the superposition.

2. In the spirit of topological field quantization it would be nice to have topological representation for the superposition and interference without any linearization. To make progress one must return to the roots and ask how the fields are operationally defined. One has test particle and it experiences a gauge force in the field. From the acceleration of the test particle the value of field is deduced. What one observes is the superposition of gauge forces, not of gauge fields.
 - (a) Let us just assume that we have two space-time sheets representing field configurations to be effectively superposed. Suppose that they are “on top” of each other with respect to CP_2 degrees of freedom so that their M^4 volumes overlap. The points of the sheets representing the field values that would sum in Maxwell’s theory are typically at distance of CP_2 radius of about 10^4 Planck lengths. Wormhole contacts representing the interaction between the field configurations are formed. Hence the analog of linear superposition does not hold true exactly. For instance, amplitude modulation becomes possible. This is however not essential for the argument.
 - (b) Test particle could be taken to be fermion which is simultaneously topologically condensed to both sheets. In other words, fermionic CP_2 type almost vacuum extremal touches both sheets and wormhole throats at which the signature of the induced metric changes is formed. Fermion experiences the sum of gauge forces from the two space-time sheets through its wormhole throats. From this one usually concludes that superposition holds true for the induced gauge fields. This assumption is however not true and is also un-necessary in the recent case. In case of topological light rays the representation of modes in given direction in terms of massless extremals makes possible to realize the analogy for the representation of quantum field as sum of modes. The representation does not depend on approximate linearity as in the case of quantum field theories and therefore removes a lot of fuzziness related to the quantum theory. In TGD framework the bosonic action is indeed extremely non-linear (see **Fig.** <http://tgdtheory.fi/appfigures/fieldsuperpose.jpg> or **Fig. ??** in the appendix of this book).
3. This view about linear superposition has interesting implications. In effective superposition the superposed field patterns do not lose their identity which means that the information about the sources is not lost - this is true at least mathematically. This is nothing but quantum classical correspondence: it is the decomposition of radiation into quanta which allows to conclude that the radiation arrives from a particular astrophysical object. It is also possible to have superposition of fields to zero field in Maxwellian sense but in the sense of TGD both fields patterns still exist. Linear superposition in TGD sense might allow testing using time dependent magnetic fields. In the critical situation in which the magnetic field created by AC current passes through zero, flux quanta have macroscopic size and the direction of the flux quantum changes to opposite.

The basic objection against TGD

The basic objection against TGD is that induced metrics for space-time surfaces in $M^4 \times CP_2$ form an extremely limited set in the space of all space-time metrics appearing in the path integral formulation of General Relativity. Even special metrics like the metric of a rotating black hole fail to be imbeddable as an induced metric. For instance, one can argue that TGD cannot reproduce the post-Newtonian approximation to General Relativity since it involves linear superposition of gravitational fields of massive objects. As a matter of fact, Holger B. Nielsen - one of the very few colleagues who has shown interest in my work - made this objection for at least two decades ago in some conference and I remember vividly the discussion in which I tried to defend TGD with my poor English.

The objection generalizes also to induced gauge fields expressible solely in terms of CP_2 coordinates and their gradients. This argument is not so strong as one might think first since in standard model only classical electromagnetic field plays an important role.

1. Any electromagnetic gauge potential has in principle a local embedding in some region. Preferred extremal property poses strong additional constraints and the linear superposition of massless modes possible in Maxwell's electrodynamics is not possible.
2. There are also global constraints leading to topological quantization playing a central role in the interpretation of TGD and leads to the notions of field body and magnetic body having non-trivial application even in non-perturbative hadron physics. For a very large class of preferred extremals space-time sheets decompose into regions having interpretation as geometric counterparts for massless quanta characterized by local polarization and momentum directions. Therefore it seems that TGD space-time is very quantal. Is it possible to obtain from TGD what we have used to call classical physics at all?

The imbeddability constraint has actually highly desirable implications in cosmology. The enormously tight constraints from imbeddability imply that imbeddable Robertson-Walker cosmologies with infinite duration are sub-critical so that the most pressing problem of General Relativity disappears. Critical and over-critical cosmologies are unique apart from a parameter characterizing their duration and critical cosmology replaces both inflationary cosmology and cosmology characterized by accelerating expansion. In inflationary theories the situation is just the opposite of this: one ends up with fine tuning of inflaton potential in order to obtain recent day cosmology.

Despite these and many other nice implications of the induced field concept and of sub-manifold gravity the basic question remains. Is the imbeddability condition too strong physically? What about linear superposition of fields which is exact for Maxwell's electrodynamics in vacuum and a good approximation central also in gauge theories. Can one obtain linear superposition in some sense?

1. Linear superposition for small deformations of gauge fields makes sense also in TGD but for space-time sheets the field variables would be the deformations of CP_2 coordinates which are scalar fields. One could use preferred complex coordinates determined about $SU(3)$ rotation to do perturbation theory but the idea about perturbations of metric and gauge fields would be lost. This does not look promising. Could linear superposition for fields be replaced with something more general but physically equivalent?
2. This is indeed possible. The basic observation is utterly simple: what we know is that the *effects* of gauge fields superpose. The assumption that fields superpose is unnecessary! This is a highly non-trivial lesson in what operationalism means for theoreticians tending to take these kind of considerations as mere "philosophy".
3. The hypothesis is that the superposition of effects of gauge fields occurs when the M^4 projections of space-time sheets carrying gauge and gravitational fields intersect so that the sheets are extremely near to each other and can touch each other (CP_2 size is the relevant scale).

A more detailed formulation goes as follows.

1. One can introduce common M^4 coordinates for the space-time sheets. A test particle (or real particle) is identifiable as a wormhole contact and is therefore point-like in excellent approximation. In the intersection region for M^4 projections of space-time sheets the particle forms topological sum contacts with all the space-time sheets for which M^4 projections intersect.
2. The test particle experiences the sum of various gauge potentials of space-time sheets involved. For Maxwellian gauge fields linear superposition is obtained. For non-Abelian gauge fields gauge fields contain interaction terms between gauge potentials associated with different space-time sheets. Also the quantum generalization is obvious. The sum of the fields induces quantum transitions for states of individual space time sheets in some sense stationary in their internal gauge potentials.
3. The linear superposition applies also in the case of gravitation. The induced metric for each space-time sheet can be expressed as a sum of Minkowski metric and CP_2 part having interpretation as gravitational field. The natural hypothesis that in the above kind of situation

the effective metric is sum of Minkowski metric with the sum of the CP_2 contributions from various sheets. The effective metric for the system is well-defined and one can calculate a curvature tensor for it among other things and it contains naturally the interaction terms between different space-time sheets. At the Newtonian limit one obtains linear superposition of gravitational potentials. One can also postulate that test particles moving along geodesics in the effective metric. These geodesics are not geodesics in the metrics of the space-time sheets.

4. This picture makes it possible to interpret classical physics as the physics based on effective gauge and gravitational fields and applying in the regions where there are many space-time sheets which M^4 intersections are non-empty. The loss of quantum coherence would be due to the effective superposition of very many modes having random phases.

The effective superposition of the CP_2 parts of the induced metrics gives rise to an effective metric which is not in general imbeddable to $M^4 \times CP_2$. Therefore many-sheeted space-time makes possible a rather wide repertoire of 4-metrics realized as effective metrics as one might have expected and the basic objection can be circumvented. In asymptotic regions where one can expect single sheetedness, only a rather narrow repertoire of “archetypal” field patterns of gauge fields and gravitational fields defined by topological field quanta is possible.

The skeptic can argue that this still need not make possible the embedding of a rotating black hole metric as induced metric in any physically natural manner. This might be the case but need of course not be a catastrophe. We do not really know whether rotating blackhole metric is realized in Nature. I have indeed proposed that TGD predicts new physics in rotating systems [K134]. Unfortunately, gravity probe B could not check whether this new physics is there since it was located at equator where the new effects vanish.

Time varying magnetic fields described in terms of flux quanta

An interesting challenge to describe time dependent fields in terms of topological field quanta which are in many respects static structures (for instance, flux is constant). The magnetic fields created by time dependent currents serves as a good example from which one can generalize. In the simplest situation the magnetic field strength experiences time dependent scaling. How to describe this scaling?

Consider first the scaling of the magnetic field strength in flux tube quantization.

1. Intuitively it seems clear that the field decomposes into flux quanta, whose M^4 projections can partially overlap. To get a connection to Maxwell’s theory one can assume that the average field intensity is defined in terms of the flux of the magnetic field over a surface with area S . For simplicity consider constant magnetic field so that one has $B_{ave}S = \Phi = n\Phi_0$, where Φ_0 is the quantized flux for a flux tube assumed to have minimum value Φ_0 . Integer n is proportional to the average magnetic field B_{ave} . B_{ave} must be reasonably near to the typical local value of the magnetic field which manifest itself quantum mechanically as cyclotron frequency.
2. What happens in the scaling $B \rightarrow B/x$. If the transversal area of flux quantum is scaled up by x the flux quantum is conserved. To get the total flux correctly, the number of flux quanta must scale down: $n \rightarrow n/x$. One indeed has $(n/x) \times xS = nS$. This implies that the total area associated with flux quanta within total area S is preserved in the scaling.
3. The condition that the flux is exact integer multiple of Φ_0 would pose additional conditions leading to the quantization of magnetic flux if the total area can be regarded as fixed. This need not to be true.

Consider as the first example slowly varying magnetic field created by an alternating running in current in cylindrical solenoid. There are flux tubes inside the cylindrical solenoid and return flux tubes outside it flowing in opposite direction. Flux tubes get thicker as magnetic field weakens and shift from the interior of solenoid outside. For some value x of the time dependent scaling $B \rightarrow B/x$ the elementary flux quantum Φ_0 reaches the radius of the solenoid. Quantum effects must become important and make possible the change of the sign of the elementary flux quantum.

Perhaps quantum jump turning the flux quantum around takes place. After this the size of the flux quantum begins to decrease as the magnitude of the magnetic field increases. At the maximum value the size of the flux quantum is minimum.

This example generalizes to the magnetic field created by a linear alternating current. In this case flux quanta are cylindrical flux sheets for which magnetic field strength and thickness oscillators with time. Also in this case the maximum transversal area to the system defines a critical situation in which there is just single flux sheet in the system carrying elementary flux. This flux quantum changes its sign as the sign of the current changes.

The notion of conscious hologram

In TGD inspired theory of consciousness the idea about living system as a conscious hologram [K21] is central. It is of course far from clear what this notion means. The notions of interference and superposition of fields are crucial for the description of the ordinary hologram. Therefore the proposed general description for the TGD counterpart for the superposition of fields is a natural starting point for the more precise formulation of the notion of conscious hologram.

1. Consider ordinary hologram first. Reference wave and reflected wave interfere and produce an interference pattern to which the substrate of the hologram reacts so that its absorption coefficient is affected. When the substrate is illuminated with the conjugate of the reference wave, the original reflected wave is generated. The modification of the absorption coefficient is assumed to be proportional to the modulus squared of the sum of the reflected and reference waves. This implies that the wave reflected from the hologram is in good approximation identical with the original reflected wave.
2. Conscious hologram would be dynamical rather than static. It would be also quantal: the quantum transitions of particles in the fields defined by the hologram would be responsible for the realization of the interference pattern as a conscious experience. The previous considerations actually leave only this option since the interference of classical fields does not happen. Reference wave and reflected wave correspond now to any field configurations. The charged particles having wormhole contacts to the space-time sheets representing the field configurations experience the sum of the fields involved, and this induces quantum jumps between the quantum states associated with the situation in which only the reference wave is present.

This would induce a conscious experience representing an interference pattern. The reference wave can also correspond to a flux tube of magnetic body carrying a static magnetic field and defining cyclotron states as stationary state. External time dependent magnetic field can replace reflected wave and induces cyclotron transitions. Also radiation fields represented by MEs can represent the reference wave and reflected wave. If there is need for the “reading” of the hologram it would correspond to the addition of a space-time sheet carrying fields which in good approximation have opposite sign and same magnitude as those in the sheet representing reference wave so that the effect on the charged particles reduces to that of the “reflected wave”. This step might be un-necessary since already the formation of hologram would give rise to a conscious experience. The conscious holograms created when the hologram is created and when the conjugate of the reference wave is added give rise to two different conscious representations. This might have something to do with holistic and reductionistic views about the same situation.

3. One can imagine several realizations for the conscious hologram. It seems that the realization at the macroscopic level is essentially four-dimensional. By quantum holography it would reduce at microscopic level to a hologram realized at the 3-D light-like surfaces defining the surfaces at which the signature of induced metric changes (generalized Feynman diagrams having also macroscopic size - anyons [K89]) or space-like 3-surfaces at the ends of space-time sheets at the two light-like boundaries of CD. Strong form of holography implied by the strong form of general coordinate invariance requires that holograms correspond to collections of partonic 2-surfaces in given measurement resolution. This could be understood in the sense that the charged particles defining the substrate can be described mathematically in terms of the ends of the corresponding light-like 3-surfaces at the ends of CDs. The cyclotron

transitions could be thought of as occurring for particles represented as partonic 2-surfaces topologically condensed at several space-time sheets.

One can imagine several applications in TGD inspired quantum biology.

1. One can develop a model for how certain aspects of sensory experience could be understood in terms of interference patterns for signals sent from the biological body to the magnetic body. The information about the relative position of the magnetic body and biological body would be coded by the interference patterns giving rise to conscious sensory percepts. This information would represent geometric qualia [K54] giving information about distances and angles basically. There would be a magnetic flux tube representing the analog of the reference wave and magnetic flux tube carrying the analog of reflected wave which could represent the effect of neural activity. When the signal changes with time, cyclotron transitions are induced and conscious percept is generated. In principle there is no need not compensate for the reference wave although also this is possible.
2. The natural first guess is that EEG rhythms (and those for its fractal generalization) represent reference waves and that the frequencies in question are either harmonics of cyclotron frequencies or linear combinations of these and Josephson frequency assignable to cell membrane (and possibly its harmonics). The modulation of membrane potential would induce modulations of Josephson frequency and if large enough would generate nerve pulses. These modulations would define the counterpart of the reflected wave. The flux tubes representing unperturbed magnetic field would represent reference waves.
3. For instance, the motion of the biological body changes the signal at the space-time sheets carrying the signal and this generates cyclotron transitions giving rise to a conscious experience. Perhaps the sensation of having a body is based in this mechanism. The signals could emerge from directly from cells: it could be that this sensation corresponds to lower level selves rather than us. Second option is that nerve pulses to brain induce the signals sent to the our magnetic body.
4. The motion of biological body relative to biological body generates virtual sensory experience which could be responsible for the illusions like train illusion and the unpleasant sensory experience about falling down from cliff by just imagining it. OBEs could be also due to the virtual sensory experiences of the magnetic body. One interesting illusion results when one swims long time in windy sea. When one returns to the shore one has rather long lasting experience of being in sea. Magnetic body gradually learns to compensate the motion of sea so that the perception of the wavy motion is reduced. At the shore this compensation mechanism however continues to work. This mechanism represents an example of adaptation and could be a very general mechanism. Since also magnetic body uses metabolic energy, this mechanism could have justification in terms of metabolic economy.

Also thinking as internal, silent speech might be assigned with magnetic body and would represent those aspects of the sensory experience of ordinary speech which involve quantum jumps at magnetic body. This speech would be internal speech since there would be no real sound signal or virtual sound signal from brain to cochlea.

5. Conscious hologram would make possible to represent phase information. This information is especially important for hearing. The mere power spectrum is not enough since it is same for speech and its time reversal. Cochlea performs an analysis of sounds to frequencies. It is not easy to imagine how this process could preserve the phase information associated with the Fourier components. It is believed that both right and left cochlea are needed to abstract the phase difference between the signals arriving to right and left ear allowing to deduce the direction of the source neural mechanisms for this has been proposed but these mechanisms are not enough in case of speech. Could there exist a separate holistic representation in which sound wave as a whole generates a single signal interfering with the reference wave at the magnetic body and in this manner represents as a conscious experience the phase?
6. Also the control and reference signals from the magnetic body to biological body could create time dependent interference patterns giving rise to neural response initiating motor actions

and other responses. Basically the quantum interference should reduce the magnitude of membrane resting potentials so that nerve pulses would be generated and give rise to motor action. Similar mechanism would be at work at the level of sensory receptors - at least retina. The generation of nerve pulses would mean kind of emergency situation at the neuronal level. Frequency modulation of Josephson radiation would be the normal situation.

3.3 Phase Conjugation, Negative Energy Topological Light Rays, And Time Mirror Mechanism

Negative energy topological light rays having phase conjugate laser waves as standard physics counterparts provide the fundamental control mechanism in the TGD based model of living matter and appears in practically every mechanism of consciousness as a basic step. In the sequel its the relationship of negative energy MEs to phase conjugate waves is discussed in detail.

3.3.1 Do Negative Energy Space-Time Sheets Have Counterparts In Quantum Field Theory?

Negative energy topological light rays seem to correspond to phase conjugate laser waves. In particular, the experiments of Feinberg [D4] are consistent with the transparency of matter for phase conjugate laser beams with photon energies above thermal energy. In optics phase conjugation requires optically non-linear system [D10]. For instance, in usual hologram the matter is optically non-linear in the sense that dielectric constant depends on the external electric field so that the electromagnetic radiation induces a change of the refraction coefficient which in turn codes for the hologram.

The dynamics of classical fields is indeed extremely nonlinear in TGD: the topological field quantization is one of the most dramatic outcomes of this non-linearity. Whether the phenomenological models for phase conjugate waves and for their generation are enough in TGD framework is an open question. The mechanism based for the generation of negative energy topological light rays based on short pulses to be discussed in this section does not seem to reduce to the framework of non-nonlinear optics.

There are also questions of principle involved.

Is phase conjugation properly understood in quantum field theories?

At the level of quantum physics negative energy photons would correspond to a system quantized in such a way that both bosonic and fermionic annihilation and creation operators have changed their roles. Negative energy photons and fermions do not correspond to (non-existing) “anti-photons” and anti-fermions. Using the terminology of Dirac’s bra-ket formalism: negative energy systems are like bras if positive energy photons are kets. Kets and bras correspond to Hilbert space and linear functionals defined in it. The space of bras is actually not equivalent with that of kets but in a well defined sense a more general concept. This conforms with the role of negative energy space-time sheets in TGD inspired theory of consciousness.

In quantum field theories time reversal transforms creation operators for fermions to creation operators for anti-fermions. Vacuum state is not changed. Time reversal in TGD sense would transform ket vacuum to bra vacuum so that the earlier creation operators annihilate the new vacuum state and genuine negative energy states result. This would suggest that negative energy states are something genuinely new and a genuine outcome of the many-sheeted space-time concept allowing either bra and ket type vacuum at a given space-time sheet. This difference might relate to matter-antimatter asymmetry whose origin is one of the deepest problems of cosmology. Perhaps dynamics favors space-time sheets containing negative energy matter instead of antimatter.

Phase conjugation and irreversibility

One interesting aspect associated with negative energy topological light rays is that they seem to be irreversible systems. On the other hand, phase conjugation can be used to eliminate perturbations on signal caused by thermal noise since the evolution proceeds from perturbed to non-perturbed

signal. This could be seen as an objection against TGD based interpretation stating that topological light rays are essentially non-dissipative structures of classical physics.

The objection can be circumvented. Classical-quantum correspondence implies that space-time physics mimics also the dissipative aspects of quantum dynamics defined by quantum jump sequences. The classical non-determinism of the basic variational principle makes this possible. Classical fields are non-dissipative structures are even able to represent information about dissipation, analogous to a written text telling a story about growth, flourishing, and decay. In fact, in TGD framework space-time itself provides symbolic classical representations for quantum jump sequences determining the subjective, experienced reality. The implications of this representative aspect for biology are highly non-trivial. For instance, phase conjugate waves could provide a fundamental mechanism of healing and error correction.

3.3.2 Is The TGD View About Phase Conjugate Waves Consistent With The Existing Wisdom?

A priori it is not obvious that the TGD based identification of phase conjugate waves as negative energy photons/topological light rays is consistent with what is known about phase conjugate waves. The best manner to check this is to translate the standard physics description of the basic mechanisms producing phase conjugate waves to the language of TGD. This should also provide new insights about how self-organization by the emission of negative energy photons proceeds in non-linear media.

Basic mechanism producing phase conjugate waves

There are two basic mechanisms producing phase conjugate waves. The physics believed to be behind these mechanisms is summarized in an enjoyable manner in the book of D. M. Pepper [D10], and in the review article of V. V. Shunov and B. Ya. Zeldovich [D48], who are pioneers of optical phase conjugation. The mechanisms rely on four-wave mixing and stimulated Brillouin scattering. Both mechanisms can be modelled using the notion of a dynamical hologram. In TGD framework dynamical hologram can be regarded as a spontaneously generated self-organizing hologram resulting by the emission of negative energy photons. The reference laser beam is quite generally pulsed. This raises the question whether the phase conjugate photons are produced by negative energy scalar wave pulses inducing negative energy “acceleration radiation” as the (em- or Z^0 -) charged particles are accelerated at the space-time sheets representing scalar wave pulses.

1. Four-wave mixing

Consider first four-wave mixing. The basic observation is that already in the case of ordinary hologram a phase conjugate beam is generated when the reference beam irradiating the hologram has a direction opposite to that of the original reference beam. The idea is to replace the static hologram with a dynamic hologram by utilizing reference beams moving in opposite directions simultaneously besides the probe beam coming from the object, so that the beams used to construct and read the hologram are simultaneously present. Either reference beam can be thought of as being scattered from the interference pattern created by the other beams and producing the phase conjugate wave. The resulting phase conjugate wave moves in a direction opposite to the probe beam, just as in the case of the ordinary hologram. The dynamic hologram is created in the non-linear medium whose properties are affected by the interference pattern formed by the beams.

TGD description would be that the interference of the three beams induces self-organization of the non-linear medium to a higher energy state representing the dynamic hologram and that this occurs by the emission of the phase conjugate wave having negative energy. This means the breaking of the second law of thermodynamics. The phase conjugate waves are dissipative structures but the dissipation takes place in a reversed direction of geometric time. To be precise, classical fields can be seen as symbolic representations for the dissipation at quantum level and possible by the non-determinism of Kähler action. This explains the strange features of phase conjugate waves.

2. Stimulated Brillouin scattering

Stimulated Brillouin scattering was first discovered to produce phase conjugate waves [D48]

by Boris Ya. Zeldowich and his colleagues, the Russian pioneers of optical phase conjugation. Only single incoming reference beam is used and the secondary reference beam in the opposite direction appears spontaneously. In this case three-wave scattering without probe beam is in question and interference pattern is solely due to the interference of the reference beams. The dynamical hologram is realized as an acoustic wave pattern from which either reference beam can be said to scatter. The phase conjugate wave is generated only above a critical power feed for the incoming beam. The incoming beam can be distorted in the directions transversal to the primary beam by allowing it to traverse an inhomogeneous glass plate. The resulting phase conjugate beam traverses back through the inhomogeneous glass plate and turns out to be free of any distortions. Obviously this demonstrates the occurrence of the time reversal.

The standard description for what happens runs as follows.

1. The process is initiated by the scattering of photons from thermal phonons in the direction of the primary reference beam and reversing thus their direction. By energy conservation the frequency difference for the two light beams corresponds to the frequency of the acoustic wave: $\Delta\omega/\omega = v/c$, where v is the sound velocity.
2. Acoustic wave generates a periodic longitudinal density gradient such that the zones of low and high density are at a distance of *half* wave length: this follows from the fact that the scattered phonons receive *twice* the momentum of photon. In this kind of situation total reflection occurs from each layer and this amplifies the secondary light beam which in turn amplifies the sound wave. A more familiar example of total reflection is the reflection of light on water having oil layer at its surface. The varying thickness of this layer gives rise to a rainbow like appearance of the scattered light. Also a phase conjugate beam is created in the process.

In TGD framework situation can be seen as a self-organization process in which the self-organizing acoustic wave gains energy by emitting negative energy photons: obviously an over unity energy production breaking the second law of thermodynamics is in question. One could even say that non-linear medium builds a primitive sensory representation of the interference pattern.

1. At the first step the photons of the primary reference beam are scattered and generate a weak secondary reference beam in an opposite direction. The resulting interference pattern in turn excites a weak acoustic wave.
2. The acoustic wave amplifies itself when phonons emit pairs of positive and negative energy photons with energies $E_1 > 0$ and $E_2 < 0$ such that the sum of their energies corresponds to the energy E_{ph} gained by the phonon: $E_1 - |E_2| = E_{ph}$. The rate of this process is proportional to the numbers N_+ and N_- of positive and negative energy photons already present in the state: the mechanism of induced emission is at work. Positive energy photons amplify the induced reference beam and negative energy photons amplify the phase conjugate wave. Also in this case one can say that the non-linear medium builds up spontaneously a dynamical hologram about the interference pattern.

The emission of negative energy photons makes possible over unity effects claimed by free energy enthusiasts. Over unity effects need not be in conflict with the standard wisdom that phase conjugate waves utilize the energy of pumping laser or probe beam. In the case of stimulated Brillouin scattering the negative energy photons are received by the population inverted lasers producing the reference beam with the consequence that particles drop to the ground state without emission of positive energy photons. In the case of 4-wave mixing the negative energy photons could be received by the laser producing the probe beam. An interesting possibility is that negative energy beams could be produced also in the direction of reference beam and pump energy from the corresponding lasers.

Over unity effects and error correction

The emission of negative energy photons makes possible over unity effects claimed by free energy enthusiasts. Over unity effects need not be in conflict with the standard wisdom that phase conjugate waves utilize the energy of pumping laser or probe beam. In the case of stimulated

Brillouin scattering the negative energy photons are received by the population inverted lasers producing the reference beam with the consequence that particles drop to the ground state without emission of positive energy photons. In the case of 4-wave mixing the negative energy photons could be received by the laser producing the probe beam. An interesting possibility is that negative energy beams could be produced also in the direction of reference beam and pump energy from the corresponding lasers.

Error correction of a signal defines a variant of the time mirror mechanism (see **Fig.** <http://tgdtheory.fi/appfigures/timemirror.jpg> or **Fig. ??** in the appendix of this book). In this case positive and negative energy signals are actually at different sides of the time mirror. The positive energy photons of the signal to be corrected annihilate with the negative energy photons of the phase conjugate signal which comes from the geometric future and is a temporal mirror image of the positive energy signal. The pulsed phase conjugate mirror would be an analog a sequence of ordinary mirrors. Pulses create a temporal sequence of time mirrors most naturally located at the ends of pulses so that positive energy photons from N : th pulse annihilate with negative energy photons from $N + 1$: th pulse.

TGD based description for the interference of reference beams

It is interesting to find whether TGD allows the field pattern resulting as a superposition of reference beams moving in opposite direction as a solution of field equations. Topological light rays do not allow this kind of field patterns. As a special case this field pattern corresponds to a transversal standing wave of form $\cos(\omega t) \times \cos(\omega z)$ (using units $c = 1$). Waves for which the interference pattern moves (say in the case of stimulated Brillouin scattering), result when the frequencies are different. These field patterns are obtained as Lorentz transforms of the standing wave pattern.

Since the Kähler current vanishes for this kind of waves the field equations state that the contraction of the energy momentum tensor with the second fundamental form vanishes. It will be found that the field equations reduce to massless wave equation in the approximation that classical gravitational effects are negligible. It is however not clear whether this kind of solution is possible as genuinely asymptotic self-organization pattern having a precisely vanishing Kähler current.

The solution ansatz is based on the assumption that the CP_2 projection belongs to the homologically non-trivial geodesic sphere S^2 of CP_2 . Let the standard spherical coordinates of S^2 be $(U \equiv \cos(\theta), \Phi)$. Let M^4 coordinates be (t, z, x, y) . The task is to imbed the electric field representing a standing wave and having components

$$E_i = \epsilon_i \times \cos(\omega t) \times \cos(\omega z) , \quad (3.3.1)$$

as a four-surface to $X^4 \subset M_+^4 \times S^2$. The polarization vector ϵ_i lies in the (x, y) -plane.

The 4-vector potential associated with this field is

$$A_\mu = \frac{\epsilon_\mu}{\omega} \times \sin(\omega t) \times \cos(\omega z) . \quad (3.3.2)$$

Note that the scalar potential $\phi = A_t$ vanishes. The induced Kähler gauge potential is of form

$$A_\mu = U \partial_\mu \Phi , \quad (3.3.3)$$

and from this the simplest ansatz (fixed only apart from a canonical transformation of CP_2) reproducing A_μ is

$$U = a \times \sin(\omega t) \times \cos(\omega z) , \quad \Phi = b \times \epsilon_\mu x^\mu , \quad ab = \frac{1}{\omega} . \quad (3.3.4)$$

In the approximation that the induced metric is flat, action density vanishes, and the energy momentum tensor has only the longitudinal components T^{tt} and T^{zz} and is proportional to the flat metric. Field equations reduce to massless wave equation in longitudinal degrees of freedom: $D^2 u = 0$ and $D^2 \Phi = 0$, $D = \partial_t^2 - \partial_z^2$. For the proposed solution ansatz they are satisfied identically.

The fact that solution has a 2-dimensional CP_2 projection means that it represents a self-organization pattern with dissipation only due to the possible non-vanishing of the Kähler 4-current and characterized by the strength of classical gravitational interaction. Classical gravitation might imply a non-vanishing Kähler four-current.

Phase conjugate photons and dark matter hierarchy

Negative energy phase conjugate photons with energies above threshold propagate in matter virtually without any attenuation. Photons below thermal threshold are masked and phase conjugate photons with wavelengths longer than the thermal wavelength absorption becomes a problem since they are absorbed. Dark matter hierarchy allows to circumvent this problem and for given thermal energy arbitrarily long wavelengths are possible for both photons and their phase conjugate. This is of key importance since remote mental interactions between magnetic and biological body are star actors in the TGD based model of living matter. There is evidence that remote mental interactions involve even galactic length scales [J86]. Same might hold true in the case of ordinary bio-control since time mirror mechanism makes possible instantaneous control although the controlling part of magnetic body is at huge temporal distance in geometric future.

3.4 Bio-Photons

MEs (massless extremals) can be carriers of light like vacuum currents generating coherent light. Bio-photons [I107, ?, I117] were the first proposed identification for this coherent light in living matter [K83]. In absence of material about bio-photons I did not develop these ideas in any quantitative detail. Situation has changed with the development of web and recently I learned from Lian Sidorov about home page containing online articles of Fritz-Albert Popp and colleagues about bio-photons and related phenomena. I am grateful for Lian also for very useful discussions and keen questions helping me to become and stay conscious about the many poorly understood aspects of the “great vision”. This homepage is recommended also to the reader and the data used below mostly derive from the articles therein [J49].

3.4.1 What Bio-Photons Are?

The web articles [J49] provide the basic facts about bio-photons and in the following I summarize my novice view about bio-photons.

Bio-photons have frequencies in the range 200-800 nm (at least). The intensity of bio-photons is extremely low: from one photon to few hundred photons/ cm^2s , which is 20 orders of magnitude weaker than common fluorescence of photophosphorence. There is evidence for coherent radiation also at longer wave length scales. A far from thermal equilibrium situation is in question: the intensity of photons is about 10^{10} times higher than that associated with the thermal visible photons at body temperature. The spectral density $f(\nu)$ defined as the counterpart of Boltzmann weight is essentially constant. This means that the effective temperature increases linearly with frequency. The experimental work of Popp and colleagues provides support for the view that bio-photons are indeed coherent light rather than some waste radiation resulting as a by-product of biological processes [J49]. Poisson statistics for the number of photons in coherent state ($p_n = \exp(-\alpha)\alpha^n/n!$) is the basic signature for the coherent light and it is found that photon counts obey this distribution.

Since $\tau \sim 1$ nanoseconds is the characteristic time constant for em emissions and absorptions at visible wave lengths, one can argue that the length scale $L = c\tau \sim 10$ cm defines the length scale below which it is not sensible to speak about localized photon and thus bio-systems must be treated as macroscopic quantum systems as far as coherent photons are considered. The timescale means also that 10^9 reactions per second can in principle catalyzed by absorption and emission of single photon in single cell: the typical number of reactions is 10^5 per second inside single cell [J49]. If bio-photons Bose-Einstein condense at magnetic mirrors (ME-magnetic flux tube pairs), extremely sharp control of biological reactions could be indeed achieved. Of course, if Bose-Einstein condensed bio-photons are most important for bio-control, one cannot exclude the interpretation of the observed bio-photons as some kind of leakage radiation from living matter (of course, these bio-photons might serve communication purposes).

Even the wave length of the visible photons, which is somewhat below the cell size, implies that molecules see classical em field like boat sees the sea. One could argue that photons as CP_2 type extremals are essentially point-like. On the other hand, if MEs are classical correlates for photons or if the classical interaction of atoms and molecules with MEs is an additional aspect of their interaction with em fields, this is not the case. The situation is not conceptually completely clear in this respect.

Interference effects provide also support for the notion of macroscopic coherent states. Popp proposes that in a healthy organism constructive interference tends to occur inside cells for bio-photons whereas destructive interference takes place outside [?, I117]. Or stating it differently, cells are able to store visible bio-photons inside them. For healthy cells the bio-photon emission and well as delayed luminescence have been found to increase as a function of cell density up to some critical density and to decrease after that. For cancer cells the intensity increases indefinitely and nonlinearly [?]. This supports the view that in cancer cell population bio-photons leak out and do not properly participate to the bio-control.

Bio-photon emission is a signature of living matter in the sense that the presence of oxidative process accompanies always the emission. This is true also for the delayed luminescence resulting as a delayed response to electromagnetic or some other perturbation. The dependence of the delayed luminescence on temperature suggests that the activation energy for the process controlling photoluminescence is roughly .53 eV [?]: this is rather near to the energy .49 eV stored in the ATP molecule. The experiments involving the insertion of inert molecules to DNA indicate that DNA is a source of bio-photons [I109], [J49]. The spectrum of bio-photons and delayed luminescence correlates strongly with various biological processes. For this reason bio-photons have several applications to bio-search, food quality control, cancer research, pharmacology and heal prophylaxis.

3.4.2 Some Phenomena Related To Bio-Photons

There are several interesting and theoretically challenging phenomena involving bio-photons.

1. Delayed luminescence [?, ?] results after an exposure to an external perturbation, which can be light or ultrasound. Delayed luminescence accompanies also biological processes like cell mitosis. The intensity of the coherent light varies from few photons to 10^5 photons/ cm^2s . The characteristic feature of the delayed luminescence is hyperbolic ($I(t) \propto 1/(1 + \lambda t)$) decay instead of the exponential one expected if incoming light just scatters from the system. The intensity involves oscillatory modulations with respect to a variable u which depends logarithmically on time coordinate ($u = \log(1 + \lambda t)$). As a function of cell density delayed luminescence increases up to some critical cell density for a healthy cell population and begins to decrease after that. For cancer cell population there is no such critical cell density.
2. Some animal populations can “see” each other. For instance, when populations of dinoflagellates become to optical contact they begin to flicker synchronously [?] (also fireflies in mangrove trees in Thailand flicker in a synchronous manner). In TGD framework this could be interpreted as evidence for magnetic mirror bridges connecting the populations such that the MEs associated with visible light propagate along them from population to another one. The bridges could also contain ELF em waves serves as synchronizers in the time scale in which flickering occurs.
3. Bacteria absorb bio-photons from nutrition media in a way that the absorption is highest for some critical cell density [?]. Female inbred daphnia in the same developmental stage and about the same size do not display the increasing bio-photon emission with increasing number [?]. Rather, a typical interference pattern of emission is observed showing maxima and minima of the bio-photon intensity at definite average distances between the animals. This could be seen as evidence for the hypothesis that the pattern of coherent light from DNA serves as kind of hologram representing 4-D template for the self-organization.

3.4.3 General TGD Based Model For Coherent Bio-Photons

MEs with light like vacuum currents indeed generate coherent photons so that bio-photons indeed have a place in TGD Universe. ATP energy about .49 eV and near to the rough estimate .53

eV for the activation energy deduced by studying the temperature dependence of the delayed luminescence [?]. This encourages to think that the MEs are closely related with the process transforming ADP to ATP serving as energy batteries (see [K62] for the TGD based model of ATP). This assumption conforms also with the fact that coherent light is associated with the oxidative process.

Bio-photons and MEs

The empirical data are consistent with the assumption that the MEs are associated with DNA (at least) and are perhaps responsible for the electromagnetic expression of the genetic information below cellular length scales (and corresponding scaled up dark length scales since there is no reason to exclude the dark variants of MEs).

MEs can carry Bose-Einstein condensates of parallel photons and the observed coherent photons represent leakage of the coherent light from cells. Both positive and negative energy MEs are possible and most naturally they are created in a pairwise manner: pairs (which do not form bound states) with a vanishing net energy and momenta are especially interesting since classical conservation laws do not pose any constraints on their creation and annihilation. The buy now-pay later energy production by feeding negative energy to the environment might be closely related with the generation of pairs of MEs which vanishing net energy. It must be emphasized that also magnetic mirrors with positive and negative energies might be in question.

Bio-photons as a signature of dark matter hierarchy

Dark matter hierarchy allows perhaps the most plausible interpretation of bio-photons and is also in spirit with the general ideas about quantum holograms. The model of EEG (actually hierarchy of them) based on dark matter hierarchy [K44] assumes that the basic structures assignable to cell have fractal scaled up variants at higher levels of dark matter hierarchy. These higher level structures could generate dark photons with energies in the range corresponding to visible photons.

At the k_d^{th} level of the hierarchy predicted by Mersenne hypothesis (one has $h_{eff} = nh$, where n is product of distinct Fermat primes and power 2^{k_d}) the wavelength of photon is scaled up by a factor 2^{k_d} with possible values of k_d fixed by the Mersenne hypothesis [K44] so that communications using “visible dark” light become possible in arbitrarily long length scales. The model for cell membrane as a sensory receptor leads to the identification of these photons in terms of dark Josephson radiation and EEG and bio-photons have identification in terms of decay products of dark Josephson photons.

MEs would have lengths of order wave length (which are below cell size for visible light), and there would be a constant distribution of MEs with respect to the direction and length of ME in the scaled up length scale interval corresponding to wavelengths of visible light. The scaled up wavelengths would correspond to the distances between source and receiver of bio-photons and $k_d \equiv 0$ would correspond to intracellular bio-photons assignable to MEs connecting sub-cellular structures having distance distribution which is more or less constant. The higher level contributions would tend to smooth out the wavelength distribution even if this is not strictly the case.

The general vision about quantum control of motor actions and sensory representations is consistent with the interpretation of positive energy MEs as space-time correlates for the emission of photons responsible for communications and negative energy MEs as correlates for phase conjugate photons involved with generalized motor control. In this framework bio-photons could result from the de-coherence of $k_d > 0$ dark photons and also as a leakage of $k_d = 0$ photons from cell interior. The synchronous flickering of dinoflagellates suggests $k_d > 0$ bio-photons are indeed present.

About the anatomy of dark MEs

MEs at the k_d^{th} level of dark matter hierarchy correspond to $r = 2^{k_d}$ -fold covering of M^4 , which are analogs of multi-sheeted Riemann surfaces (note that the meaning of “sheet” in this context is different from that in the context of many-sheeted space-time (see **Fig.** <http://tgdtheory.fi/appfigures/manysheeted.jpg> or **Fig.** 9 in the appendix of this book). Each sheet of the covering

corresponds to scaled up variant of the space-time sheet associated with ordinary photon with r -fold size scale and classical energy E/r . This allows to interpret the formula $E = \hbar(k)f = r\hbar_0 f$ at space-time level.

r -fold MEs could be generated by r -sheeted magnetic flux sheets containing Bose-Einstein condensates of bosonic ions in quantum coherent manner such that each sheet is responsible for one sheet of r -fold ME.

The decay to ordinary photons can occur in two ways.

1. In de-coherence a downwards scaling of the structure by a factor $1/r$ and collapse to a single sheeted structure with energy E representing ordinary photon occurs. Since frequency is replaced with rf and \hbar by \hbar_0 , energy does not change.
2. The multi-sheeted structure could also decay to r single sheeted structures with energy E/r .

Constraint to the intensity of the vacuum current

The decomposition of dark MEs to r ordinary MEs cannot correspond to the generation of coherent photons by vacuum current since the frequencies involved would be much lower than the frequencies $\sim 10^{14}$ Hz associated with the visible light. Thus one can restrict the consideration to $k_d = 0$ case. This process might however also occur as the experimental findings of Gariaev [I85] about laser light induced radio-wave emission to be discussed in the next section indicate.

The source of photons at the second end of ME is responsible for the Bose-Einstein condensate of photons associated with ME. These photons are not observed unless some kind of leakage occurs at the receiving end of ME: suppose that this does not happen. Physical intuition suggests that the light-like vacuum currents associated with MEs generate coherent states of ordinary photons and that these photons leak out and give rise to the observed bio-photons. MEs lose their energy in the process and become eventually vacuum extremals.

These assumptions allow to deduce a constraint to the intensity of the vacuum current associated with ME.

The interaction Lagrangian of the vacuum current with the vector potential of the quantized photon field is given by

$$L_{int} = e \int d^4x j \cdot A \quad (3.4.1)$$

where the indices of the second quantized vector potential and vacuum current have been dropped away for simplicity and the units $\hbar = c = 1$ are used and e denotes the electromagnetic coupling.

This interaction term describes an infinite number of harmonic oscillators coupled to an external oscillatory force. In each Fourier mode initial vacuum state is transformed to a coherent state which is an eigenstate of the corresponding annihilation operator. By standard calculations [B15] one can deduce the expression for the effective classical vector potential defined by the eigenvalues of the annihilation operators is given by

$$\begin{aligned} A(x, t) &= \frac{ie}{(2\pi)^3} \int d^3k \frac{1}{2\omega(k)} \exp[-ik \cdot x - i\omega(k)t] j(k, \omega(k)) , \\ \omega(k) &= |k| . \end{aligned} \quad (3.4.2)$$

The eigenvalues $\alpha(\epsilon, k)$ for the annihilation operator $a(\epsilon, k)$ associated with polarization ϵ is given by the expression

$$\alpha(\epsilon, k) = \frac{ie}{2(2\pi)^3 \omega(k)} \epsilon \cdot j(k, \omega(k)) . \quad (3.4.3)$$

$\alpha(k)$ indeed has the dimension length to $3/2$ as it should be on basis of the commutation relations in the continuous momentum basis. If finite quantization volume with a discrete momentum basis is used, $\alpha(k)$ contains additional $1/\sqrt{V}$ factor guaranteeing that the eigenvalues are dimensionless.

The eigenvalues characterizing the coherent states are proportional to the massless Fourier components of the vacuum current so that the intensities of bio-photons determining the values of the parameters $\alpha(k)$ allow to deduce the on mass shell Fourier components of the light like vacuum current. Of course, the coherent field of photons is superposition of several interfering contributions coming from MEs with light like currents and only the sum of these contributions appears in the detected field.

Sucking force in TGD framework

The mechanism by which sun flowers turn towards Sun as well as the attraction between cells are not very well understood processes. Popp and Chang introduce as an explanation an interaction which they call sucking force [?]. The notion is inspired by the assumed analogy with the vacuum cleaner which is a particular kind of a pump. The pressure gradient along the tube of the vacuum cleaner generates airflow towards the tube. Since pumping is always done when dissipative processes are present, a process involving essentially the dynamics of quantum jumps is in question and the force does not have counterpart at the level of the irreversible classical dynamics.

In case of em fields radiation pressure gradient replaces the ordinary pressure gradient. The counterpart of the tube of vacuum cleaner is naturally a ME along which Bose-Einstein condensed photons propagate and are absorbed at the second end of the tube, most naturally cell in case of visible photons. The pumping implies an attractive force between living systems connected by MEs. This force would be present at all levels of the length scale hierarchy. The force is only between systems having common characteristic frequencies so that they can be connected by MEs. For instance, this force could explain why tRNA carrying amino-acids finds the corresponding mRNA in the translation of DNA to proteins.

The sucked MEs can propagate along larger ME serving as an em bridge to the receiving system and the absorption most naturally corresponds to the annihilation with MEs of opposite energy. Both negative and positive energy MEs can be sucked. The sucking of negative energy MEs makes possible very flexible buy now-pay later type energy consumption: the user (say DNA) generates pairs of positive and negative energy MEs and utilizes the positive energy MEs, whereas the negative energy MEs are received by the payer, most naturally mitochondria where they annihilate with the positive energy MEs produced by ATP process.

3.4.4 The Interpretation Of Bio-Photons And EEGAs Decay Product-Of Dark Josephson Radiation

The foregoing considerations have been classical in the sense that MEs have been taken as a model for bio-photons. The model of EEG [K44] leads to the prediction that cell membranes act as Josephson junctions generating Josephson radiation. If the cell membrane is assumed to be almost vacuum extremal which brings in classical Z^0 field proportional to em field and raises the energy scale of Josephson junction from 0.07 eV for neuron to UV range. The electromagnetic charge of ion must be replaced with effective charge which is non-vanishing also for neutral atoms and molecules.

The energies of dark photons involved are in visible and UV range for most ions in the range of resting potentials just as the energies of bio-photons. The model also predicts correctly the peak frequencies of maximal sensitivity for the four kinds of photoreceptors. The frequencies are inversely proportional to the value of Planck constant characterizing the cell membrane. Quite generally, the value of Planck constant characterizes the evolutionary level of neuron.

Both EEG photons and bio-photons can be identified as decay products of dark Josephson photons producing either a bunch of EEG photons or single bio-photon. The frequency modulation of Josephson frequencies provides a general coding of sensory percepts and other information in terms of Josephson radiation communicating this data to the magnetic body. This modulation could also explain the observed periodic modulations.

3.4.5 TGD Based Model For The Delayed Luminescence

The TGD based model for the delayed luminescence is based on two mathematical observations:

1. The intensity of coherent photons must be proportional to the number of positive energy MEs and hyperbolic decay results naturally if MEs annihilate pairwise. The most natural possibility is that positive and negative energy MEs annihilate in a pairwise manner.
2. Oscillatory behavior in the variable $u = \log(1 + \lambda t)$ results if there is a feedback mechanism generating or destroying MEs or MEs with a rate which is the time derivative dF/dt of a periodic function $F(u)$. The interaction with supra currents via magnetic induction could be the mechanism in question.

The essential difference as compared to the models of Popp and Yan [?], whose TGD variant will be also considered below, is that quantum coherence for photons is not assumed in the time scales of order seconds characterizing the decay of the delayed luminescence.

Basic observations

Before going to the analytic formulation, it is good to work through the basic mathematical and physical ideas of the model first and connect them with the general vision about homeostasis as many-sheeted ionic flow equilibrium.

1. Negative/positive energy ME is a correlate for photon absorption/emission. Thus the distribution of the coherent photons reflects the kinetics for MEs with lengths corresponding to the wave lengths of visible light. MEs and ME pairs are generated by the interaction with the external perturbation, say electromagnetic field. The annihilation of positive and negative energy ME pairs is energetically very natural mechanism changing the number of MEs. There must be an interaction between supra currents and MEs and magnetic induction is very attractive interaction mechanism. The induction current LdI/dt associated with super conducting circuit should generate or destroy MEs or ME pairs with rate which on dimensional grounds must be proportional to $eLdI/dt$.
2. At the level of frequencies hyperbolic decay law predicts a $1/f$ power spectrum for frequencies $f \ll \lambda$. $1/f$ noise is almost [E1] [D1] and I have already earlier proposed that the dynamics of the mind like space-time sheets, for instance MEs, might explain it [K87, K86].
3. Hyperbolic decay suggests that the interaction involving two MEs is involved since $dI/dt = kI^2$ gives $1/(1 + \lambda t)$ behavior. The basic reaction would be the annihilation of positive and negative energy MEs with rate proportional to $n_+ \times n_-$. The essential assumption is that in the absence of an external perturbation MEs are generated or annihilated only in pairs. It is essential that given positive energy MEs can annihilate with *any* negative energy ME: hence positive and negative energy MEs cannot appear as only self-annihilating tightly bound pairs. If only annihilation occurs the assumption implies that the difference of $n_+ - n_- = n_0$ for the numbers n_+ and n_- of positive and negative energy MEs is a constant of motion. This can be also interpreted as stating that absorption and emission cancel each other in homeostatic equilibrium. In the asymptotic stationary state only n_+ is non-vanishing.
4. A correction periodic with respect to the variable $\log(1 + \lambda t)$ to the decay rate result if there is additional mechanism generating ME pairs. The rate for the generation of ME pairs must be of the general form

$$\frac{dn(\text{ME pair})}{dt} = \frac{dF(u)}{dt} , \quad (3.4.4)$$

where $F(u)$ is a periodic function of the variable $u = \int (n_+ + n_-) dt$

Concrete physical model

One can develop the physical model further by utilizing the general ideas related to DNA, to the model of nerve pulse and EEG and fractality.

1. *The events preceding delayed luminescence*

The general view about how magnetic bodies control biological body and receive sensory data from it suggests how external perturbation induces delayed luminescence. External perturbation induces sensory communications to a relevant magnetic body at some level of dark matter hierarchy. Magnetic bodies react and induce generalized motor action which at DNA level means expression of some genes requiring the unwinding of some portions of DNA. Delayed luminescence is associated with this portion and corresponds to Josephson radiation of photons at various levels of dark matter hierarchy.

2. *How delayed luminescence is induced?*

Popp and Yan have proposed two models of the delayed luminescence based on time dependent harmonic oscillator in time dependent driving force [?]. Both models are constructed by hand to produce the hyperbolic decay law using the flexibility of harmonic oscillator Hamiltonian. The objection is that the frequency parameter in the first model producing the hyperbolic decay law is in ELF range whereas photons have frequencies in the visible range. The authors consider also a model based on two coupled harmonic oscillators reproducing the oscillatory behavior. The problem now is that the model does not seem to approach to the first model at any limit.

Dark matter hierarchy allows to invent a modification of the harmonic oscillator model so that it overcomes the worst difficulties of principle associated with the models [?] and allows also a concrete physical interpretation.

1. The presence of dark matter hierarchy justifies the assumption that the coherence of the harmonic oscillators at visible frequencies (with a natural time scale of 10^{-14} seconds) is maintained in time scales of minutes: nanosecond would look the maximally optimistic assumption about coherence time in the standard physics context. For instance, coherence time of 2 minutes would correspond to the dark matter levels with $r = 2^{k_d}$, $k_d = 56$.
2. Bio-photons would result as an outcome of the de-coherence of dark Josephson photons associated with MEs corresponding to frequencies $1/f \sim$ few minutes to a single-sheeted MEs corresponding to visible ordinary light. The hyperbolic decay rate and its logarithmic oscillatory behavior are still put in by hand but the model to be discussed can explain these features.
3. A possible TGD based interpretation for the frequency modulation is that frequency corresponds to a voltage over Josephson junction. The variation of the voltage over Josephson junction is in turn analogous to that occurring during nerve pulse and the change of sign for the voltage would have a natural interpretation in terms of the generation of negative energy MEs. Josephson radiation would thus generate both positive and negative energy dark MEs. This would mean that the basic frequency $\omega_J = Q_{eff}eV$ of Josephson would vary slowly and induce a variation of the fundamental frequency of Josephson radiation over the range of visible frequencies (actually also lower frequencies can be present but with smaller intensity). This frequency would in turn define the fundamental frequency associated with the coherent light emitted by MEs and the variation would explain why the spectrum covers smoothly over the range of visible frequencies.
4. The connection with nerve pulse generation suggests that an analog of nerve pulse propagating along DNA double strand accompanies the unwinding of the double strand. The general model for the quantum control by magnetic body [K44] would suggest that the magnetic body generates W ME inducing charge entanglement between magnetic body and DNA double strand (or either of the strands). When the state function reduction of this entanglement leads to a state in which double strand (or either strand) has an anomalous em charge, double strand becomes unstable against unwinding and in this process positive and negative energy neutral MEs are generated.

5. The unwound portion of DNA double strand acts as a Josephson junction at $k_d = 0$ level of hierarchy and generating visible Josephson radiation for which MEs are space-time correlates. Bio-photons correspond to coherent photons generated by the vacuum currents associated with $k_d = 0$ MEs. The Josephson junction has scaled up dark variants just as the cell membrane and similar process occurs also at the higher levels of dark matter hierarchy just as in the case of cell membrane [K44]. Dark variants of visible photons at various levels of dark matter hierarchy are generated.

3. Josephson radiation has positive and negative energy MEs as space-time correlates

During gene expression period when unwinding of DNA double strand occurs, both negative and positive (inertial) energy MEs must be generated and negative energy MEs could be assigned with the change of the sign of voltage over the Josephson junction.

If MEs carry constant transversal electric and magnetic fields, they must carry effective charges at their boundaries. The rotating wormhole throats at the boundaries of MEs and connecting them to larger space-time sheets serve as sources of the electric and magnetic field. These larger space-time sheets could but need *not* be MEs with opposite energy.

The annihilation of MEs (ME pairs) must occur dominantly by collisions of MEs (ME pairs) moving in opposite directions. Annihilation would mean at the level of photons (CP_2 type extremals) that positive and negative energy CP_2 type extremals would fuse to wormhole contact by topological sum. The resulting two light-like causal horizons assignable to the wormhole contact would carry quantum numbers of photon and its phase conjugate. The resulting ME pairs cannot generate appreciable coherent light since it could be regarded essentially as a dipole like structure with the distance between currents of order CP_2 length.

MEs should be parallel and in very regular spatial configuration in order that their contributions to the coherent light interfere constructively. If MEs are associated with unwound DNA, this might be implied by the regular structure of unwound DNA. The simplest guess is that MEs are orthogonal to the DNA strands. Hence a constructive interference occurs only when DNA is in an unwound state and is thus active. This is certainly the case when DNA is transcribed. The prediction is that also the intronic portions of DNA expressed only electromagnetically must be unwound in the active state. Similar constructive interference is expected in the case of axonal MEs generating coherent light at ELF frequencies.

Interesting questions relate to the interpretation of the positive and negative energy MEs. One possibility is that negative energy MEs suck energy from metabolic sources. At $k_d = 0$ level the sources would be mitochondria. If positive energy MEs are interpreted in terms of sensory communications. What comes in mind are communications with basic building bricks of RNA molecules needed in the transcription and cyclotron frequencies of DNA and RNA nucleotides could serve as their signatures.

4. Could magnetic induction generates or destroy MEs?

Magnetic induction is the fundamental mechanism for the interaction of MEs and supra current circuits. That magnetic induction should generate MEs is a rather natural assumption since changing current induces radiation and MEs represent topologically quantized counterparts of the classical radiation fields. Periodic oscillations in variable $\log(1 + \lambda t)$ result if the magnetic induction (generation of emf in the circuit) for the current is accompanied by generation of MEs such that the number of MEs generated per unit time is proportional to $eLdI/dt$, where I is Josephson current. This is possible only if DNA double strand is unwound and has Josephson junctions only at the other end or both ends. If Josephson currents are the only currents in the circuit one obtains precisely the required type of term to the differential equation for the numbers of the positive and negative energy MEs. Since Josephson current is sinusoidal and has constant intensity, the prediction is that the amplitude of the oscillatory perturbation is constant unless the density of the supra current carriers varies also.

Hyperbolic decay

The kinetic equations for n_0 and n_- are

$$\frac{dn_+}{dt} = \frac{dn_-}{dt} = -kn_+n_- . \quad (3.4.5)$$

This gives

$$n_+ - n_- = n_0 = \text{constant} . \quad (3.4.6)$$

Thus the difference for the numbers of positive and negative energy MEs is conserved. Using this condition, one can write the equations in the form

$$\frac{dn_+}{dt} = \frac{dn_-}{dt} = kn_+ \times (n_0 - n_+) . \quad (3.4.7)$$

The solution of this equation is

$$n_+(t) = n_0 A \frac{1}{A - \exp(-u)} , \quad n_-(t) = n_0 \left[\frac{A}{A - \exp(-u)} - 1 \right] , \quad (3.4.8)$$

$$A = \frac{n_+(0)}{n_+(0) - n_0} , \quad u = n_0 k t .$$

What is nice that the solution approaches asymptotically automatically to $(n_+ = n_0, n_- = 0)$. If n_0 is negative the roles of n_+ and n_- are changed and the solution approaches to $(n_+ = 0, n_- = n_0)$. There are reasons to believe that n_0 defines the number of *positive* energy MEs in the normal situation for the living matter and generating the coherent bio-photons.

The small values of the parameter u correspond to

$$t \ll \frac{1}{n_0 k} ,$$

and since the intensity of coherent light is proportional to n_+ one has in this region the hyperbolic decay

$$n_+(t) = n_0 \times \frac{A}{A-1} \times \frac{1}{1 + \lambda t} ,$$

$$\lambda = \frac{k}{A-1} . \quad (3.4.9)$$

The non-vanishing of the intensity of the coherent light in the absence of external perturbations requires symmetry breaking in the sense that one has $(n_+ = n_0, n_- = 0)$ in the stationary situation. This corresponds naturally to the symmetry breaking associated with the functioning of DNA. Only the strand is expressed (chemically or electromagnetically) and the conjugate strand serves as the source of energy. The conjugate strand can give part of the negative energy to the environment, most probably to the mitochondria, and the strand is the only user of the positive energy.

Periodic corrections to the decay rate

One should understand also the logarithmic oscillations [?] in the time scale of seconds from first principles. This variation must correspond to an endogenous feedback which generates ME pairs just like the exogenous perturbations generate ME pairs. The existence of this kind of process is consistent with the observation of a delayed luminescence associated with various biological functions such as mitosis.

On basis of previous considerations suppose that there is small feedback term at the right-hand side of the equation for dn_+/dt of the general form

$$\frac{dn_+}{dt} = \frac{dn_-}{dt} = -kn_+n_- + \epsilon \frac{dF}{dt} , \quad F = F(\int (n_+ + n_-) dt) . \quad (3.4.10)$$

Here ϵ is assumed to be a small parameter. For $n_+ \gg n_0$ one has in good approximation $n_+ + n_- = 2n_+$. For small value of ϵ one can integrate the perturbation in good approximation to give

$$\begin{aligned} \Delta n_+(t) &\simeq \epsilon F(\int (n_+ + n_-) dt) \simeq \epsilon F(\int 2n_+ dt) , \\ \int 2n_+ dt &\simeq K \times \log(1 + \lambda t) , \quad K = 2 \frac{n_0}{\lambda} \times \frac{A}{A-1} . \end{aligned} \quad (3.4.11)$$

If $F(u)$ is a periodic function then also a periodic logarithmic term results.

The general vision about many-sheeted ionic flow equilibrium in which MEs can act as Josephson junctions allows to make guesses about the origin of the feedback term. Suppose that the differential equations for n_+ and n_- contain a term proportional to the net voltage eV over a Josephson junction:

$$F\left(\int (n_+ + n_-) dt\right) = eV . \quad (3.4.12)$$

The motivation for this assumption is the conviction that there must be a coupling between the dynamics for MEs and many-sheeted ionic current circuits. Note that the dimensions are same for dn_+/dt and voltage eV in the natural units $\hbar = c = 1$.

The model already discussed indeed produces the required oscillatory behavior.

1. Suppose that the Josephson junctions are at the ends of the unwound DNA double strand current loop traversing transversally all n_+ positive energy MEs transversal to DNA strand and n_- negative energy MEs transversal to the conjugate strand. Assume also that that both positive and negative energy MEs contributes constant potential difference $-eV_0$ along strand besides oscillating contribution. Note that MEs are not assumed to act as Josephson junctions between strands.
2. Assume that the potential differences over the Josephson junctions are same. The net ir-rotational potential difference through the junction at the end is thus $(n_+ + n_-)eV_0/2$.

Under these assumptions the Josephson current through the junction is given by

$$I = I_0 \sin\left(\frac{eV_0}{2} \int (n_+ + n_-) dt\right) . \quad (3.4.13)$$

This current runs through the entire circuit and induces to the net electric potential difference through the junction a rotational magnetic induction term $\Delta V = LdI/dt$. Also Ohmic and capacitance terms can be present but for simplicity let us assume that they are absent. Under these assumptions one has

$$F\left(\int (n_+ + n_-) dt\right) = eI_0 \sin\left(\frac{eV_0}{2} \int (2n_+ - n_0) dt\right) . \quad (3.4.14)$$

This term has the required dependence on time and gives in a good approximation a periodic logarithmic term. The prediction is that the amplitude for the intensity of oscillation is constant.

TGD inspired modification of the model of Popp and Yan for the delayed luminescence

As discussed earlier, the basic objection against the model of delayed luminescence proposed by Popp and Yan [?] is the long coherence time of order few minutes. For instance, $k_d = 56$ level of dark matter hierarchy allows 2 minute time scale. The hyperbolic decay law can in turn be understood in terms of annihilation of positive and negative energy MEs, and the annihilation of MEs induced by magnetic induction interaction having interpretation in terms of absorption of photons explains logarithmic oscillations as a signature of Josephson current.

This picture suggests that a modification of the model of Popp and Yan [?] could make sense also in TGD framework. The physical picture of the model is that the frequencies of the visible photons are frequency modulated slowly in ELF time scale and the modulation function depends logarithmically on time. Physically this would correspond to the modulation of the lengths of the MEs which generate the coherent visible light so that frequency scale varies. The amplitude of the frequency modulation must be below measurement resolution. This model predicts that the temporal behavior of the intensity is same for all visible frequencies.

Frequency modulation means the addition of a small and slowly varying part to the visible frequency. The modulation is a logarithmic function

$$u(t) = \log(1 + \lambda t)$$

of time. The parameter λ characterizes the hyperbolic decay rate and is of order few Hz typically. The functional form of the modulation is ad hoc.

The frequency modulation of the visible frequency ω_0 reads as

$$\begin{aligned}\omega(t) &= \omega_0 + \omega_1 \times F(u) , \\ F(u) &= u + f(u) .\end{aligned}\tag{3.4.15}$$

where $f(u)$ is periodic function: also this assumption is ad hoc. $\omega_1 \ll \omega_0$ guarantees that modulation is small: the variation of the frequency ω_0 should be below the experimental frequency resolution.

Consider now a quantitative model for this based on the modification of the discussion in [?]. The Hamiltonian for the time dependent harmonic oscillator driven by time dependent force and having time dependent vacuum energy $\beta(t)$ reads as [I159]

$$H(t) = \omega(t)a^\dagger a + fa^+ + \bar{f}a + \beta(t) .\tag{3.4.16}$$

Standard commutation relations are satisfied and coherent states are eigen states of annihilation operator ($a|\alpha\rangle = \alpha|\alpha\rangle$) and the eigenvalues of annihilation operator satisfies same equation of motion as the annihilation operator:

$$\frac{d\alpha}{dt} = i\omega(t)\alpha + f(t) .\tag{3.4.17}$$

The general solution of this equation is

$$\begin{aligned}\alpha(t) &= \exp(-i\phi(t)) \left[\alpha(0) + \int_0^t f(t_1) \exp(i\phi(t_1)) dt_1 \right] , \\ \phi(t) &= \int \omega(t) dt = \omega_0 t + \omega_1 \int F(1 + \lambda t) dt .\end{aligned}\tag{3.4.18}$$

Energy is constant of motion for coherent states (homeostatic equilibrium), that is $\omega n = \omega_0 n_0$ which gives

$$n(t) = n_0 \frac{\omega_0}{\omega(t)} .\tag{3.4.19}$$

This gives for the intensity of the light in delayed emission

$$\begin{aligned}I(t) &\propto \frac{dn}{dt} = -\frac{n_0 \omega_0}{\omega^2} \frac{d\omega}{dt} \\ &= -\frac{n_0 \omega_0 \omega_1}{\omega^2} \frac{dF}{du} \frac{1}{1 + \lambda t}\end{aligned}\tag{3.4.20}$$

The amplitude of frequency modulation should be below experimental resolution so that one has $\omega(t) \simeq \omega_0$ in excellent approximation. This gives the approximate expression

$$\frac{dn}{dt} \simeq -\frac{n_0\omega_1}{\omega_0} \frac{dF}{du} \frac{1}{1+\lambda t} \quad (3.4.21)$$

The simplest choice for $F(u)$ is $F(u) = u$ and gives hyperbolic decay. If $F(u)$ is of form $F(u) = u + \lambda_1 \sin(u)$, an oscillatory behavior

$$\frac{dn}{dt} \simeq -\frac{n_0\omega_1}{\omega_0} [1 + \lambda_1 \cos(\log(1 + \lambda t))] \frac{1}{1 + \lambda t} \quad (3.4.22)$$

results.

3.4.6 Kirlian Effect

Kirlian effect [I71] is a candidate for one particular instance of the proposed $f_{ELF} \rightarrow f_h$ transformation. Kirlian photography uses high voltage in kV range alternating at frequencies of order kHz. The frequency is 1024 Hz in so called gas discharge visualization method (GDV) developed by Korotkov [I143]. The Kirlian response of living matter differs from the response of non-living matter in that it varies in much wider limits and correlates with the state of organism. Thus it seems that the explanation as a mere passive coronal discharge cannot be correct. The presence of water is essential for the effect and for some reason this has led to skeptics to announce that effect involves nothing which would not be understood by standard skeptic science.

Korotkov [I143] believes that GDV involves a holistic psycho-physiological rather than a purely local biological response which should be same for living and non-living matter. Korotkov has developed GDV as a diagnostic tool using the hypothesis that GDV picture is kind of a hologram reflecting the state of the entire organism. GDV seems to indeed serve as a rough diagnostic tool allowing to deduce with certain reliability whether organism is healthy or not [I71]. The idea about DNA as a hologram is consistent with Korotkov's vision.

The frequency used in GDV is very near to the resonance frequency of synchronous neuronal firing. This suggests that the process involves neural activity and genetic expression as assumed also in the model for the discovery of Gariaev that laser light at 2 eV photon energies induces delayed emission of radio-waves. In this case the emitted light could be bio-photons resulting from the de-coherence of dark photons, for instance ELF photons at $k_d = 47$ level of dark matter hierarchy for 5 Hz frequency [K44]. This would conform also with the continuum of the emitted spectrum.

3.5 Bio-Photons, Radio Waves, And Genetic Regulation

Bio-systems could generate holograms in much more concrete sense than the wetty and hot and noisy character of this environment would suggest: even mechanisms generating laser beams could be there. The findings of Peter Gariaev and collaborators described in the article "The spectroscopy of bio-photons in non-local genetic regulation" [I85] provide a new support for the notion of many-sheeted DNA. The findings also lead to a concrete model for how bio-photons affect many-sheeted DNA, and in this manner induce a generation of coherent radio waves and ELF waves. Moreover, a concrete model for how bio-systems act as many-sheeted lasers at various wavelengths emerges.

In polarizing laser-radio wave spectroscopy (PLR-spectroscopy) laser light scatters from the target substance. In the experiments of Gariaev *et al* red light ($\lambda = 632.8$ nm, 1.9595 eV) generated by He-Ne laser is used. There are two orthogonal polarizations correlated in intensity in such a way that the total intensity remains constant. After the interaction of one mode with the target substance, the reflected light is returned to the optical resonator, where the re-distribution of the intensity of these modes occurs. One of the laser modes, at a certain mode of generation, is able during the interaction with the target substance to induce modulated radio waves of a wide spectrum correlated with the modulations of the optical modes of the laser radiation. The modulation depends on rotational fluctuations of micro-structural components (say, domains of

crystals) and of their optical activity. The PLR-spectrum is present also for in-organic materials. For biological targets there is spectral memory effect present, which means that the radio wave radiation continues even when the laser beam is not present anymore.

The general situation is very similar to that encountered in the case of delayed luminescence [?], and an attractive assumption is that laser light acts as an external perturbation inducing gene expression requiring unwinding of DNA which involves generation of dark photons at various levels of dark matter hierarchy as Josephson radiation. Also cyclotron radiation from magnetic bodies is expected to be present just and the interpretation in terms of scaled up variants of EEG [K44] might make sense. Dark photons at $r = k_d^{th}$ level of dark matter hierarchy correspond to 2^{k_d} -sheeted MEs and their decay to single-sheeted MEs representing ordinary coherent light with frequency $f(k) = f/r$ yields ELF and VLF photons.

3.5.1 Frequency Spectrum Of Radio Waves

The frequency interval of the radio emission settles down at the 1 MHz. The PLR-spectrum is depicted in figures 1 and 2 of [I85] for apofillit crystal. The frequency spectrum for the radio waves has a modulated fractal structure suggesting that spectrum is superposition of spectra which consist of harmonics $n_1 f_h - n_2 f_l$ of higher frequency f_h modulated by harmonics of scaled down frequency $f_l = x f_h$. Almost identical copies of a piece of length about

$$\Delta f \sim 100 \text{ Hz}$$

appear in a sequence as the pictures 1 and 2 of [I85] for the spectrum of apofillit crystal in 1560-1860 Hz range demonstrate. This suggests the presence of harmonics of basic frequencies perhaps shifted by a constant amount. Cyclotron and spin flip transitions in magnetic field suggest itself.

There is also gross structure consisting of peaks in scale of kHz suggesting harmonics of frequency of order kHz. For wheat seed (picture 3 of [I85]) the strongly expressed frequency ranges are identified as 800-900 Hz (to my personal opinion the band is 300-900 Hz), 1700-1900 Hz, 2400-2600 Hz, 3600-3800 Hz (to my personal opinion a wider frequency range 1700-2200 Hz is strongly expressed). There is also strongly expressed frequency band below 300 Hz. Also the spectrum of high polymerization DNA sample from calf thymus (picture 4 of [I85]) shows a clear peak at 2400-2600 Hz and less pronounced peaks at lower frequencies.

The radio wave radiation from DNA samples is accompanied by specific effects on bio-systems such as ab-normally fast germination and re-vitalization of seeds. Thus it seems that the radio wave radiation is able to restore the genetic control apparatus and the vitality of the seeds.

3.5.2 Basic Questions

The model proposed by Gariaev *et al* [I85] for the PLR effect is based on the phenomenological notion of photon localization dating back to the experimental findings made 1985 [D7] suggesting that photon beam can be concentrated in a narrow tube under some circumstances. This is strongly reminiscent of ME (massless extremal), which is essentially “topological light ray” along which photons propagate. MEs are the basic element in TGD based quantum model of living matter.

Concerning the modelling of the PLR effect, the basic questions to be answered are following.

1. How could one understand the modulated fractal like spectrum of the radio waves radiation? What is the origin of the frequency scales present in the spectrum and what gives rise to modulatory structure?
2. How does the scattering of coherent light on DNA induce the radio wave emission and how one can understand the correlation between polarizations?
3. How does the spectral memory effect result and what is the mechanism causing the biological effects accompanying the radio waves?

In the following TGD based answers to some of these questions are discussed.

3.5.3 How To Understand The Spectrum?

The finding that the width of the basic unit of the spectrum is about $\Delta f = 100$ Hz would suggest that the mechanism involves magnetic transitions in Earth's magnetic field, whose nominal value can taken to be $B_E = .5$ Gauss for definiteness. The corresponding space-time sheet would be $k = 169$ and correspond to p-adic length scale $L(169) \simeq 5$ micrometers.

1. Miracle length scales and the coiling hierarchy of DNA

Above this p-adic length scale are four miracle length scales $k = 151$ (electron Compton length for $k = 151$ corresponds to cell membrane thickness of about 10 nm), $k = 157, 163$, and $k = 167$ related by scaling $L(k) = 2^{(k-169)/2} \times L(169)$ to $L(169)$. These p-adic primes correspond to the so called Gaussian Mersennes $G_k = (1+i)^k - 1$, $|G_k| \simeq 2^k$, which are complex counterparts of ordinary Mersenne primes. Since ordinary and Gaussian Mersennes are fundamental for TGD based elementary particle physics, one expects that the same is true in biological length scales. The coils inside coils inside... structure of the chromosomes could correspond to a quantum control hierarchy of these four space-time sheets, and the transitions of ions between cyclotron (magnetic) states at these space-time sheets would generalize ordinary cyclotron (magnetic) transitions.

If these space-time sheets are also magnetic flux tubes carrying magnetic field satisfying flux quantization condition the corresponding field strengths are obtained by scaling $B(k) = 2^{169-k} B_E$. Cyclotron frequency scales are scaled up in the same manner: $f_c(k) = 2^{169-k} f_c(169)$.

1. For $k = 167$ the cyclotron frequencies are scaled up by a factor 4. What is interesting is that for bosonic Mg_{++} ion cyclotron frequency is $f(169) = 25$ Hz so that for $k = 167$ the cyclotron frequency would be 100 Hz. Mg^{++} is indeed important biological ion, especially so for the functioning of DNA [I115]. Hence the 100 Hz approximate fractal periodicity might relate to the cyclotron harmonics of Mg_{++} ions. There are also other cyclotron frequencies present and for bosonic ions many of these frequencies are in alpha band so that 40 Hz periodicity would also suggest itself. Different frequency scales imply a super-position of the scaled up harmonics spectra.
2. For $k = 163$ the factor is 64 and frequency range 10 – 100 Hz for ionic cyclotron frequencies is scaled up to 640 – 6400 Hz. These transitions could explain the large scale features of the spectrum with characteristic scale of kHz.
3. For $k = 157$ the factor is $2^{12} \simeq 4000$, which means that the frequencies for ions are in MHz range, which corresponds to the upper bound for the frequency range of radio waves.
4. For $k = 151$ the factor is $2^{18} \simeq 10^6/2$ and the cyclotron frequency for proton is about .15 GHz and in microwave range. Microwaves are in a fundamental role in TGD based view about bio-control.

2. Is the radio-wave spectrum a superposition of many-sheeted magnetic transition spectra?

The simplest hypothesis is that the radio-wave spectrum is a superposition of relatively simple magnetic spectra for several ions and having the same general shape.

1. The spectrum of a given ion results, when the ion drops from a cyclotron state n_1 at $k > 169$ magnetic flux tubes to cyclotron states n_2 at $k = 169$ magnetic flux tube such that the longitudinal momentum along tube is conserved or is very small. If the magnetic flux tube is of finite length L , the longitudinal energies are given by $E_n = n^2 \pi^2 / 2mL^2$, L the length of the magnetic flux tube. If the length of the magnetic flux tube is considerably longer than the magnetic length, magnetic energy gives only a small contribution to the energy and can be neglected unless Δn is very large.
2. The frequencies of the photons resulting in this manner are given by

$$f(k) = n_1 f_c(k) - n_2 f_c(169) = [2^{169-k} \times n_1 - n_2] \times f_c(169) .$$

Here $f_c(169)$ varies in the region 1-100 Hz for ions other than proton and for proton one has $f_c(169) = 300$ Hz. Quite generally one has $f_c = 300Z/A$ Hz, where A is the mass number of ion and Z its charge. Effectively the harmonics of the ionic cyclotron frequencies at Earth's magnetic field modulate the scaled frequencies at $k < 169$ magnetic flux tubes.

3. A more general model allows the variation of the magnetic field strengths from their nominal values, so that one has the formula

$$f(k) = [a(k)2^{169-k} \times n_1 - a(169)n_2] \times f_c(169) .$$

Here $a(k)$ characterizes the scaling relating the actual value of the magnetic field value to its nominal value.

Under these assumptions it could be possible to understand the basic fractal like characteristics of the spectrum. There is a killer test for the model: one should be able to identify individual lines of the PLR-spectrum as differences $S(k_1, A) - S(k_2, A)$ of the magnetic spectra $S(k_i, A)$ for various ions (A denotes the atomic number). PLR in principle means a possibility to do many-sheeted spectroscopy and might provide the Golden Road to many-sheeted physics.

3.5.4 Many-Sheeted Radio-Wave Laser Excited By Ordinary LaserLight

The idea of many-sheeted laser allows to consider several mechanisms explaining the findings.

1. The visible laser light beam could pump the ions from the magnetic flux tubes to cyclotron states at $k < 169$ space-time sheets wherefrom they drop to $k = 169$ space-time sheet and generate coherent photons at radio wave frequencies.
2. Alternatively, laser light might stimulate directly the dropping of pre-existing ions from space-time sheet $k < 169$ to $k = 169$. The emitted light can indeed give rise to stimulated emission just like in the case of the ordinary laser. Entire many-sheeted cascades $k_1 \rightarrow k_2 \rightarrow \dots \rightarrow k = 169$ of emissions analogous to cascades of emissions from the decay of excited atomic states are possible.
3. The analogy with the delayed luminescence forces to ask whether the same basic mechanism is behind both phenomena. If so, the connection between laser irradiation and radio wave generation is less direct involving the reaction of magnetic body. The motor action of the magnetic body would induce gene expression and unwinding of DNA strand and generation of Josephson radiation responsible for the communications to the magnetic body at frequencies $nf_c \pm f_J$: this radiation would give rise to bio-photons as already discussed. The correlation of its polarization with the polarization of laser light is not plausible. If the part of the generalized EEG involving harmonics nf_c of cyclotron frequencies responsible for the control of DNA by magnetic body results as a direct response to the laser irradiation, the correlation between the polarizations of laser light and radio waves is conceivable.
4. The fact that the radio wave radiation is accompanied by biological effects suggests that radio-waves result from dark photons for which energies are above thermal threshold at room temperature. The mechanism would be the decay of r -sheeted ME to r separate MEs with energy determined by frequency in the usual manner. Biological effects would not be produced by the radio-waves but by high energy dark photons with energies in UV range (300 Hz corresponds to ~ 5 eV).

He-Ne laser produces miracle wave length

The wavelength of laser photons corresponds to about 632.48 nm, which is quite near to the p-adic length scale $L(163) = 640$ nm in the approximation $L(151) = 10$ nm. This is one of the p-adic miracle frequencies. This observation suggests that the laser light interacts resonantly with $k = 163$ space-time sheet and somehow generates radio waves in this process. Therefore the general rule of thumb for how to make many-sheeted-ness manifest would be simple. A radiation with wavelength of order p-adic length scale induces resonantly a flow of ions to space-time sheets for which the

zero point kinetic energy is of the order of magnitude of the photon energy. This hypothesis is in principle testable by looking whether the laser beams with wavelengths given by p-adic length scales are in a special position.

Does the energy of photons from He-Ne laser correspond to the zero point kinetic energy of electron at $k_2 = 73$ space-time sheet

The space-time sheet corresponding to the secondary electronic Compton length scale $L_{2,e}(k = 73) \setminus = "L_e(146) = \sqrt{5}L(146) \simeq 10/32 \simeq 3.12$ Angstroms, is rather near to the length of single DNA base (10 DNA triplets correspond to the length of 10 nm). In this case electron's zero point kinetic energy is $\simeq 2$ eV and is the same as the energy of photons in the laser beam used in the experiments. This suggests that the kicking of electrons from $k = 163$ space-time sheet to $k = 73$ secondary space-time sheet is the first step of the process. After this step electron drops back to $k = 163$ space-time sheet and emits essentially the original wavelength so that laser action results. The probability for the occurrence of this step is amplified by the presence of coherent laser light (stimulated emission mechanism).

The correlation between the polarizations of radio-waves and laser photons

The polarizations of the radio waves correlate with the polarization of the laser light. This is the case if the radio waves result in a process, which kicks electron from $k = 163$ space-time sheet to $k = 73_2$ space-time sheet. The simplest possibility is that the kicking process involves a coherent interaction with the other ions at $k = 163$ magnetic flux tube inducing the dropping of these ions to $k = 169$ magnetic flux tube accompanied by the radiation at frequency corresponding to the difference of the magnetic energies. One can imagine also a second possibility. Since the electron is kicked to a super-conducting space-time sheet associated with the DNA base, the information about polarization is not lost into a thermal noise, and the electron dropping back to $k \leq 169$ space-time sheet still carries it. Therefore the dropped electron could induce the dropping of ion to $k = 169$ space-time sheet generating still polarized radio waves.

In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant \hbar_{eff} so that cyclotron energy would be liberated.

Quantum coherence produces intense radio wave and ELF laser beams

Because of the presence of a large number of Cooper pairs/bosonic ions in the same state at $k \leq 169$ space-time sheet, the process occurs coherently and the rate is proportional to the square N^2 of the number N of the bosonic ions/Cooper pairs in the system.

The radio waves and ELF radiation produced in ordinary magnetic transitions at $k = 169$ space-time sheet is quantum coherent in the length scale defined by wavelength at least and propagates inside the tubes defined by ELF or VLF MEs. This radiation is obviously ideal for biological communication and control purposes. This suggests that bio-photons propagating inside low frequency MEs with frequencies in kHz range act just like a laser beam and induce emission of radio waves in the proposed manner.

Also $k > 169$ space-time sheets can be involved and produce radiation ULF wave lengths. For instance, maser beam could resonantly interact with structures in the size range of roughly 1 mm-1 m (microwave wavelengths) and kick electrons to $k = 157$ magnetic flux tubes (say) where cyclotron energy scale is of correct order of magnitude. Thus a very complex many-sheeted spectroscopy analogous to atomic and molecular spectroscopies is predicted.

Phantom DNA effect

A further mysterious looking effect involved with the experiments is phantom DNA effect. There is also an elastic scattering of the coherent from irradiated DNA and the simplest mechanism is

the kicking of electrons to the $k_2 = 73$ space-time sheet and dropping back so that they regenerate laser photons with essentially the original wave length. When one removes the DNA from the chamber containing it, and irradiates it by laser light, a weak pattern of scattered light is still produced: as if there were a kind of phantom DNA there.

A possible explanation for the effect is that the removal of DNA is not complete but leaves some non-atomic space-time sheets associated with the DNA to the chamber. If $k_2 = 73$, $k = 163$ and $k = 167$ space-time sheets are left besides the $k = 169$ space-time sheets associated with the magnetic field of Earth, the proposed model indeed predicts scattering. Sooner or later however the ionic densities from these space-time sheet should leak from the volume of the chamber and the scattering is not observed anymore. A killer test for the model is whether the removal of the Earth's magnetic field artificially destroys the effect (and also PLR effect).

3.5.5 Is The Radio Wave Band Structure For Wheat Seed A Scaled-Up Version Of The Band Structure Of EEG?

In the model for the hierarchy of EEGs (and generalizations of EEG) based on dark matter hierarchy the band structure of EEG can be understood in terms of resting voltage of cell membrane and cyclotron frequencies in the magnetic field of Earth [K44]. Same ions should contribute to the radio wave spectrum also if it corresponds to a scaled up version of the cyclotron frequency part of EEG. Therefore it is interesting to look at the band structures of the radio-wave spectrum for wheat seed represented in the figure 3 of [I85] assuming that $k = 163$ magnetic flux tubes are in question.

1. By scaling the frequency bands of figure 3 of [I85] one finds that the lowest band below 250 Hz can be identified as the counterpart of delta band in EEG ($f < 3.9$ Hz).
2. The region 300 – 900 Hz corresponds to the range 4.7 – 14 Hz covering theta and alpha bands. Actually the band extends to about 1300 Hz so that it contains also beta frequencies up to 20 Hz. In the figure 4 representing the spectral memory there is minimum of intensity at about 700 Hz which corresponds to about 11 Hz so that alpha and beta bands separate from each other.
3. The band 1700 – 2100 Hz corresponds to the range 26-32 Hz and also to beta frequencies. 2400 – 2600 Hz band corresponds to 40 Hz thalamo-cortical resonance band 37.5 – 40.6 Hz.
4. 3600 – 3800 Hz band corresponds to the range 56.3 – 59.5 Hz. The DNA spectrum of figure 4 of [I85] contains also a band around 4800 Hz: this frequency corresponds to 75 Hz and to the cyclotron frequency of ${}^4\text{He}_+$ ion, which is not bosonic ion unless it is an exotic one. This is somewhat questionable interpretation. For $k = 157$ it could be identified as scaled up variant of delta band around 1 Hz which corresponds to DNA cyclotron frequencies. There are no further peaks visible in the figures of [I85]. Protonic cyclotron peak should be visible at frequency of 19.2 kHz not represented in the figures.

As already noticed, the 100 Hz periodicity visible in the spectrum of apofillit crystal (figure 2b) could be due to the harmonics of the Mg_{++} cyclotron frequency $f_c(167) = 100$ Hz at $k = 167$ space-time sheet. There is also 50 Hz periodicity and a weaker 25 Hz periodicity and these periodicities could correspond to even and odd cyclotron harmonics of Mg_{++} at $k = 169$ space-time sheet. Even harmonics for ordinary cyclotron transitions are suppressed by parity conservation.

3.6 Conscious Hologram And Remote Mental Interactions

The notion of conscious hologram allows also a unified description of remote mental interactions.

3.6.1 Big Vision

The notion of conscious hologram, which is based on the generalization of the notion of Feynman diagram, provides a general view about remote mental interactions.

1. Brain can be seen as a part of a gigantic dynamical and fractal brain consisting actually of the entire universe. The same mechanisms that work at the brain level work also at larger length and time scales. Brains/bodies serve as “neurons” for the magnetospheric selves receiving information from several brains/bodies. In particular the fusion of the mental images defined by similar structures can give rise to stereo-consciousness, and the notion of species consciousness and even multi-organ consciousness associated with various kinds of organs makes sense.
2. The notions of super-genome and hyper-genome provide a concrete view about how transpersonal levels of self-hierarchy are realized. Super genes are magnetic flux sheets containing sequences of genes like text lines at the page of book. Hyper genes are flux sheets containing sequences of super-genes belonging to different organisms as genetic text lines. This picture conforms nicely with and generalizes Sheldrake’s species memory and “alike likes alike” rule. It also suggest a concrete realization of remote biological mental interaction based on activation of gene expression and nerve pulse activity.

The flux sheets associated with super-genome and hyper-genome have fields strengths of magnetic field of Earth. The correlation of the quality of remote cognition performance with sidereal time [J86] leads to the hypothesis that also the flux quanta of galactic magnetic field couple somehow to living matter.

3. Besides time mirror mechanism charge entanglement realized in terms of W MEs is a basic mechanism of remote mental interaction. The simplest model for the generation of nerve pulse is based on quantum jump leading to a state in which Bose-Einstein condensate of Ca^{++} and/or Mg^{++} becomes exotically ionized and generates charge flow through cell membrane. Quite generally, charge entanglement would be part of the ordinary bio-control realized in terms of Ca^{++} waves. Charged entanglement provides also a mechanism for the sharing of mental images between magnetic body and biological body. There is no reason why this mechanism could not work also at the level of other remote mental interactions than those that we are too familiar with to realize that remote mental interactions are in question. The typical time 13-15 seconds associated with the remote realization of intentions by Qigong masters [J71] could correspond to a typical duration of W entanglement.

The models for bio-photons bio [I107] and Gariaev’s findings [I85] suggest a tentative model for how remote mental interactions proceed. Charged entanglement via W MEs makes possible sharing of mental images. After a reduction of entanglement the generation of positive and negative energy MEs occurs and involves time mirror mechanism making possible remote metabolism and communications of declarative memories. In the case of ordinary bio-control magnetic body utilizes the metabolic energy resources of biological body.

4. Association mechanism works also for remote mental interactions and is even in the case of brain based on MEs and magnetic flux tubes with neuronal firing and metabolic activities being side products of the this mechanism.
5. One of the strange findings about remote mental interactions is that remote viewer can receive information about an object for which she knows only coordinates, which as such are meaningless numbers to her. It is also commonly reported that erroneous readings or interpretations of the target tend to propagate to other viewers. These findings suggest that magnetospheric (earthly or galactic magnetosphere could be in question) dynamical multi-brained selves act as kind of relay stations mediating the remote contact between remote viewer and object. If some brain knows the meaning of the coordinates of the target, this is enough to connect remote viewer to the correct target.

Empirical support for the notion of multi-brained collective levels of consciousness comes from the experiments of Mark Germaine [J98]. An operator and a subject person were involved. The stimulation of the subject person consisted of a sequence of identical sounds containing now and then an odd-ball stimulus (now silence). The odd-ball stimulus generated an event related potential (ERP) visible in EEG and reflecting the conscious reaction. The operator was in a second room and by simple toss of coin decided whether to observe the stimuli in the computer monitor or not.

The stimuli appeared in the computer monitor one second before they were heard by the subject person.

What was found that when the operator saw the odd ball stimulus from the computer monitor, the ERP was weaker on the average. An 11 Hz periodicity was the major component in the difference profiles.

The simplest explanation is that the brains of both the operator and of the subject person belong to a larger multi-brained self and that the evoked response represented partially the reaction of this self. When this multi-brained self had already seen the stimulus through the operator's eyes, it was not so surprised to hear this stimulus again through the ears of the subject person, and ERP was weaker.

The appearance of the 11 Hz periodicity suggests that this frequency is an important correlate for the entanglement of the subject person's mental images with those of some multi-brained magnetospheric self. The cyclotron frequencies of most bosonic ions in Earth's magnetic field are in alpha band so that the finding is consistent with the vision about a fractal hierarchy of generalized EEGs associated with the dark matter hierarchy [K44]. The notion of hyper-genome provides a detailed model for how transpersonal levels of self hierarchy control the behavior of groups of individuals. The hypothesis could be tested by looking whether the gene expressions of individuals having close personal relationship but not in a direct personal contact correlate.

3.6.2 Sketch For What Could Happen In A Typical Remote Viewing Experiment

Consider a situation in which a system consists of remote viewer A, person B knowing the position of target T and the coordinates XYZ for it. B gives the coordinates XYZ for person C in turn giving them to the remote viewer A. The following simplified sketch assumes that communication channels are permanent and that the intentions involved with the process are realized as p-adic space-time sheets in the brain of A, and very probably involve p-adic MEs as representations of the intentions.

1. Remote viewer A, person B knowing having target-XYZ association as two mental images in his brain, and target T have permanent bridges to a magnetospheric multi-brained self M. Therefore M knows the target-XYZ association via the brain of B.
2. Remote viewer A is a client of the multi-brained self M using the remote sensory services provided by M. A-M contact is more or less permanent: this is what it means to have the ability to remote view. Minimum requirement is the existence of magnetic flux quanta connecting A to M. The sharing of mental images requires generation of entanglement, say charge entanglement by W MEs. This would correspond the most primitive passive mode of remote viewing. W mode allows to share also mental images of primitive living systems like plants, and even those assignable to system regarded usually as in-animate. The reduction of charge entanglement makes possible remote mental interaction since resulting charge non-equilibrium generates currents: generation of nerve pulse and Ca^{++} waves would represent basic example of this kind.
3. One can imagine also active mode of remote viewing and this could be involved with telepathy: in this case M would not be involved. This mode involves intentional action (p-adic MEs are transformed to their real variants) and classical communications with the geometric past/future using neutral negative/positive energy MEs could realize declarative memories/"declarative" precognition as well as motor action based on classical communications using symbolic representations. The model for bio-photons suggests that Z^0 and em MEs are generated after the reduction of charge entanglement. The ability to predict reasonable well the personal future could rely on "declarative" pre-cognition. The evolution from bicameral mind to modern consciousness [K105] could have proceeded from a mere sharing of mental images by W MEs to complex classical symbolic communications involving also neutral MEs.
4. Since M cannot be assumed to have anything comparable to a nervous system, A-M communications should rely on sharing of mental images. That is, the intention of A (p-adic space-time sheet in brain of A perhaps) to remote view and the questions of A about the

target would be shared by M. T-M communications could involve classical communication with light velocity generating magnetospheric sensory representation about the target by self-organization. The 13-17 second delay of remote mental interactions [J71] could correspond to the typical duration of charge entanglement. Target could be also “non-living”: it is quite possible that magnetospheric selves form sensory representations also about “non-living” matter. The finding that meteor sounds have frequency spectrum in the 40 Hz band of thalamocortical resonance frequencies, rather than in the predicted 20-20.000 Hz band, supports the view that magnetospheric sensory representations at 40 Hz resonance band are associated also with the non-living matter [K65], [F8]. Also the vision about dark matter hierarchy conforms with the idea about Earth’s magnetosphere as a living organism.

5. Remote viewing by the sharing of mental images means that there are no sensory receptors associated with the passive mode of remote viewing: no such receptors have been identified [J101]. Various physiological correlates (say EEG patterns) of remote viewing should be reactions to the shared mental image rather than direct correlates of it. If primary sensory qualia are at the level of sensory organs, remote viewing differs from hallucinations in that there is no feedback to the retinas from cortex responsible for “qualiafication”: this could provide be a clear-cut test. At least in the case of living targets the laws that govern the ordinary sensory perception should hold true for the remote viewing. For instance, the known correlation of the AC performance with the spatial and temporal entropy gradients of the target should hold true for living targets. Even in the case of a non-living target similar correlation holds true if the sensory perception of magnetospheric selves obeys same laws as that of ours: there is some evidence for the correlation of the entropy of non-living target with the AC performance [J101].

3.6.3 Why It Is So Difficult To Take Remote Mental Interactions Seriously?

By the fractality of consciousness the anatomy of quantum jump represents the general structure of the life cycle of any self. First totally entangled multi-verse is generated, then state function reduction and preparation by self measurements occur and the end result is a maximally un-entangled state. This is what analysis following the birth of an intuitive idea is. By the fractality of consciousness same process occurs also in longer time scales since the sequences of quantum jumps effectively integrate to single quantum jump and the sequences of these effective quantum jumps have similar structure.

This somewhat pessimistic vision is based on the standard Shannonian notion of entropy. For algebraic entanglement, which is the only possible entanglement between different number fields, number-theoretic entropies can be non-negative and Negentropy Maximization Principle does not force de-entanglement in this case. Thus it might be possible to avoid the unavoidable looking decay, and living systems might apply it routinely.

Dark matter hierarchy provides justification for the hierarchy of moments of consciousness with increasing averaging geometric durations and for the idea of quantum parallel dissipation. The simplest view is that life cycle corresponds at the highest level of the personal dark matter hierarchy single moment of consciousness and lower levels would define the mental images as sequences of quantum jumps. This would explain why we “know” that we existed also yesterday. Entropy growth would apply only to the sequences of lower level quantum jumps defining sub-selves so that mental images would age but could also reincarnate.

Depending on whether one believes in Shannonian world order or takes seriously the notion of number theoretic entropy, one ends up with two almost diametrically opposite visions: evolution as an emergence of selfish *resp.* unselfish selves. Both views explain in their own manner why it is so difficult for a modern man to take remote mental interactions seriously.

Pessimistic view: evolution as a gradual de-entanglement?

From the Shannonian view point and assuming no dark matter hierarchy, the evolution of self at any level is also a decay process leading to alienation and loneliness at the level of mental images.

What is consoling is that selves can lose consciousness and wake-up into new childhood. One can say that a healing sleep after a hard day is possible at all levels of self hierarchy.

Ancient myths inspire to think that this vision applies to the evolution of modern subjective consciousness from more collective consciousness. Jaynes has proposed a vision about how bicameral consciousness [J85], in which the voices of Gods talking to people were talking to everyone, gradually transformed to the modern subjective consciousness. TGD based articulation of Jaynes's views based on the notion of semi-trance is discussed in the last chapters of this book.

The basic theme of the pessimistic view about evolution would be the gradual de-entanglement. The ancient world has survived in fairy tales. In this world remote mental interactions like telepathy, remote healing, and witchcraft were every-day life. Incredible-to-us physical feats like building of pyramids might have been made possible by the liberation of energy and coherent momentum in the formation of collective bound state entanglement. The rhythmic work songs helping to generate body synchrony are a remnant from this period, but are not sung in modern IT companies. Also the strange intra-terrestrial creatures and spirits of magnetosphere; fairies, trolls, eagle-headed humans, dreadful snakes, ..., populated this world. Shamans talk completely seriously to the anthropologists about these creatures without any doubt about their reality. The human sacrifices for Gods, which look extremely cruel to us, were not experienced as such since these people were not individuals with ambitious plans for a lifelong career.

This development has a parallel at the level of personal life. Fairy tales are told to children, who themselves are living the period of oneness. Then these children grow, become more and more rational and analytic. After the days of willpower, intentional resources are depleted and they gradually lose their ability to make choices and there is not much to choose anymore, and become often also lonely and separated. Gradual physical decay adds its own flavor to this process.

The entire evolution could be seen as wake-ups or re-births, bursts of potentialities from which only few are selected during gradual de-entanglement accompanying self-organization, with dissipation serving as the Darwinian selector. Huxley's view about brain as a filter makes sense: our brains would minimize the sharing of mental images, which does not aid controlled behavior and survival, and thus make us modern individuals. For instance, the mysterious ability of birds and fishes to migrate back to their birth places might actually involve quantum entanglement.

Inhibition by various neurotransmitters could be seen as a measure for the degree of de-entanglement. Inhibition would act as the filter, which de-entangles the brain from other brains and the body from the bodies of other life forms. During hallucinatory experiences, generated by say drugs, inhibition would "fail". The degree of inhibition indeed increases, as one climbs along evolutionary tree and in human brain most of the neural activity is inhibition, a rather strange finding difficult to understand in the framework of the ordinary neuroscience.

In accordance with ontogeny recapitulates phylogeny principle, this evolution could be seen as an increasing dominance of inhibition during the development of individual leading from spontaneous children to well-behaved and highly controlled adults. Only in some periods of life inhibition fails: during puberty, in physical death and in great turning points of life. Indeed, puberty and physical death are sometimes accompanied by poltergeist phenomena. Physical death may also be accompanied by telepathic phenomena.

Optimistic view: evolution as an emergence of un-selfish selves?

If the notion of the number-theoretic entropy makes sense and the view that life cycle itself corresponds to a single moment of consciousness at the highest level of personal dark matter hierarchy, the view about the growing role of inhibition as an indication of continual de-entanglement is incorrect.

Rather, the increasing dominance of inhibition would indicate the increasing role of an entanglement during which neuron receives negative energy MEs, and thus provides energy for some another system by buy now and let others pay mechanism. This would mean a gradual emergence of un-selfish neurons making possible increasing flexibility and co-operativity. This of course applies also at higher levels like family and society. The increasing role of inhibition could also reduce the remote mental interactions having negative effects (witchcraft might involve genuine remote mental interactions). The Jaynesian view about the evolution of subjective consciousness could be seen as a gradual development from a child like selfish self sending negative energy to an adult unselfish self able to receive negative energies and co-operate.

The primitive society as an analog of single muscle becomes a flexible system in which responsibilities are maximally delegated to the individuals and God's voice does not anymore give direct commands and advice. The evolution of social structures and culture is essentially evolution of hyper-genome coding for the transpersonal levels of consciousness. The irony is that the replacement of God's voice with symbolic communications leads to the illusion that there is nothing but the lonely individuals although the emergence of complex social structures suggests just the opposite.

In this picture the loneliness of the post-modern man might be seen as a degeneration, a return to a selfish child like behavior paralleling the disappearance of transpersonal levels of consciousness. In entanglement either party is the one who gives energy, and the refusal of the average market economy self to entangle by receiving negative energy or sending positive energy makes it hard to entangle at all. A society of lonely skeptics is the outcome. In this view, the failure of inhibition is a degeneration phenomenon, a return to childhood, and involves strong fluxes of negative energy to the environment generating irreversible phenomena like poltergeist and inducing telepathic experiences.

3.6.4 About The Physiological Correlates Of Anomalous Cognition

In the article "Physiological correlates of Psi cognition" of Charles Tart [J35] some apparently contradictory findings about physiological correlates of anomalous cognition are described besides the experimental findings of Tart. Changes in EEG, galvanic skin response, finger pulse, and basal skin resistance are examples of possible candidates for the physiological correlates of remote mental interactions.

The findings are following.

1. The first class of experiments involves two persons: subject and agent. The agent is subjected to various kinds of stimuli inducing emotional response: sudden sounds, painful stimuli as in the experiments of Targ, etc.. Subject person is typically in a sound proof room and tries to remotely cognize when subject person experiences these stimuli. Various candidates for the physiological correlates are measured. The physiological correlates typically express a heightened arousal. For instance, in the experiments of Tart [J35] galvanic skin response occurred more frequently, and EEG became more complex with more beta waves and fewer alpha, theta, and delta waves.
2. In the second kind of experimental arrangement remote viewing or telepathy is involved but the second person, if present at all, is not subject to any stimuli inducing emotional reaction. Now the physiological correlates tend to be characteristic for a relaxed state of mind. The increase of the basal skin resistance is one such correlate.

At first these findings might seem to be contradictory. The paradox disappears if sharing of mental images is in question and if the mental images induce same emotional response in the subject person as in the agent.

The remotely perceived (possibly sub-conscious) stimulus or remote anticipation of the stimulus induces in the subject person an emotional reaction having as a correlate the reduction of skin resistance. In the experiments of Tart [J35] both the real electrical stimulus experienced by the agent and the electrical stimulus guide by the operator to an electrical resistance instead of the agent, generates the arousal in the subject. This requires that both the operator, agent, and subject belong to the same multi-brained self so that the reaction of the subject can be interpreted as a kind of conditioned reaction of the multi-brained self expressed via the body of the subject.

3.6.5 Local Sidereal Time, Geomagnetic Fluctuations, And Remote Mental Interactions

The article of J. Spottiswoode [J86] discusses two strange findings about remote mental interactions.

1. There is a statistical tendency of the anomalous cognition (AC) performance to concentrate in a 2 hour period around 13.30 of the local sidereal time (ST), which is the time measured

using as a reference distant stars and thus running at a slightly different rate than the solar time: the lag is $\Delta T = 24/365$ hours ~ 3.7 minutes during 24 hours.

2. The anticorrelation between the level of geomagnetic fluctuations and AC performance has also a maximum during 2-hour period around ~ 13.30 ST.

The fact that AC performance is associated with the same sidereal hour suggests the identification of the galactic magnetosphere as a conscious involved with remote cognition. For interstellar and galactic magnetic fields cyclotron time scales correspond to the time scales of human consciousness so that also these magnetic flux quanta could receive sensory input from biosphere and control it.

Support for the role of magnetospheric consciousness

The so called ap index measures the intensity of the fluctuations of the Earth's magnetic field. If the magnetosphere is a conscious entity, ap index can be interpreted as a measure for the level of arousal of the magnetospheric mind. The negative correlation between ap and AC performance tells that AC is most probable, when the magnetosphere is in a "calm state of mind". This is natural since only in this kind of situation the noise masks minimally the signals from the galactic magnetosphere.

The local magnetic noise produced by the modern high tech environment is much stronger than the geomagnetic noise but this does not matter. If artificial magnetic fields correspond to $k_d = 0$ level of the dark matter hierarchy, they have no effect on higher levels of dark matter hierarchy. Note that one has $h_{eff} = nh$, where n is product of distinct Fermat primes and power 2^{k_d} .

Is there an ELF signal from the special direction masked usually by the geo-magnetic noise?

The obvious question is why the anticorrelation between anomalous cognition effect size and ap index is highest at 13.30 ST? What this finding means that a particular portion of the sky defined by a definite longitude is above the head of a successful anomalous cognizer independently of the time of year. Thus there should be something special in a direction at this longitude.

The simplest explanation for these findings goes as follows.

1. Suppose that there is a higher level conscious entity at the direction 13.30 ST at the galactic magnetic body such that various cyclotron frequencies involved with the communications with this entity correspond to a typical time scale of the anomalous cognition. This conscious entity could have size of galaxy or it could correspond to a flux tube of galactic magnetic body using the cognizer and target as sensory receptors and motor instruments just as our magnetic body might use neurons of our brain or our body parts.
2. Anomalous cognition could involve positive and negative energy signals to this magnetic body and back so that essentially instantaneous AC events would be possible.
3. The information transfer between two kinds of flux tubes is made possible by the topological condensation of the flux tubes of B_E or its dark variant at those of the galactic magnetic field or its dark variant and would be maximal when both are nearly vertical. Also geomagnetic noise would be transferred via wormhole contacts to the flux tubes of the galactic magnetic field and perturb these communications. Both AC and its anticorrelation with geomagnetic noise would be maximal when the flux tubes of magnetic fields in question are approximately parallel. Since the flux tubes of B_E are approximately vertical, this the case when the galactic center is directly above the head. This would explain the special value of sidereal time. One can say that the magnetic flux tubes of the interstellar magnetic field define kind of cosmic umbilic cord which might serve as a correlate for the tunnel experience associated with NDEs.
4. If signals to geometric past and back are involved the time and length scales would measured using 10^5 years as unit. The signals themselves would be coded using frequencies characterizing time scales of neural consciousness as kinds of ripples to the very slowly oscillating

background signal just as perturbations due to nerve pulses interfere with EEG rhythms. Since remote psychokinesis and anomalous cognition should rely on the same mechanism, the first guess for the time scale involved with these signals is as the time lag of 13 to 17 seconds involved with the remote realization of intentions by Qigong masters [J71]: the interpretation as a typical duration of charge entanglement was already proposed. It would not be surprising if the time scale of entanglement would determine also the scale of cyclotron frequencies. This would mean the importance of the frequencies in the range .06 to .08 Hz for anomalous cognition.

The following scenario suggests a possible manner to understand the time scale of remote PK.

1. If protonic cyclotron transitions generate the low frequency MEs in the range $f_1 = .06$ Hz to $f_2 = .1$ Hz, the strength of magnetic field must be in the range 13 to 17 nT (nanotesla). The magnetic flux tubes of an interstellar magnetic field in a direction with a longitude defined by 13.30 ST should be in question.
2. The ends of the magnetic flux quanta attached to structures within the inner magnetosphere co-rotate with Earth. The resulting twisting presumably tends to induce additional noise to the interstellar magnetic field or Earth's magnetic field or both.
3. The strengths of the typical disturbances of Earth's magnetic field are in the range 50-200 nT [J86]. The average strength for a given frequency component for the fluctuating part of the Earth's magnetic field increases at low frequencies. At the alpha band the strength of the Fourier component of fluctuations is about $\sqrt{B^2(f)} \simeq 1 \text{ pT}/\sqrt{Hz}$ at alpha frequencies. Interestingly, the magnetic perturbation produced by brain at alpha band has a peak, which is slightly above the fluctuations of the Earth's magnetic field. This is perhaps not an accident in light of the expected role of the alpha band in remote mental interactions. The strength for the Fourier component $B^2(f)$ for the fluctuations of $B^2(t)$ [J21] is roughly $\sqrt{B^2(f)} \simeq .1 \text{ nT}/\sqrt{Hz}$ at $f_2 = .01$ Hz, and about $\sqrt{B^2(f)} \simeq 10 \text{ nT}/\sqrt{Hz}$ at frequency $f_1 = .06$ Hz.

What puts bells ringing is that the noise level 50-200 nT is by a factor 4 to 15 higher than the required interstellar static magnetic field at the lower limit corresponding to the 17 second period. These findings suggests that magnetic fluctuations tend to mask the positive effect of the interstellar magnetic field on AC. Only when the strength of the fluctuations of the Earth's magnetic field at the cyclotron frequency of the interstellar magnetic field reduces sufficiently below the strength of the interstellar magnetic field, the masking effect is small enough.

What is the origin of the interstellar magnetic field?

The idea about the magnetic umbilic cord connecting distant astrophysical objects to a single quantum coherent whole is sensible in the many-sheeted space-time. The TGD based model for the galaxy formation assumes that the ordinary matter results from the decay of cosmic strings, which are objects carrying extremely strong magnetic fields (magnetic flux tubes and these objects belong to the same solution family of field equations). These cosmic strings form a complex network. For instance, this model explains gamma ray bursters [K112].

The huge energy production of gamma ray bursters is consistent with their huge distance only if one assumes that the energy is liberated in jets. In TGD framework the gamma ray bursts can be identified as jets resulting in the decay of split cosmic strings giving rise to the ordinary matter. The bursts are indeed known to originate in the regions, where new stars are born. This picture supports the idea about the existence of a fractal magnetic flux tube network connecting different astrophysical objects, and left as a remnant from cosmic strings, when their magnetic energy transformed to the ordinary matter and gave rise to the birth of stars. This network could give rise to galactic nervous systems in turn combining to the central nervous system of the Universe.

Surprisingly, this picture might be consistent with the constraints on the direction and magnitude of the interstellar magnetic field.

1. According to the online lecture of S. Oliver [E6], the measured values of the interstellar magnetic fields depend somewhat on the method with which they are measured (this might be a signal of the many-sheetedness). The interstellar magnetic fields vary in the range $B_u = 1$ mGauss– $B_l = .1$ μ Gauss [E8], which means that both electronic and protonic cyclotron time scales for all interstellar magnetic fields correspond to time scales relevant for human consciousness. The minimal values of k_d are $k_d = 53$ for B_u and $k_d = 66$ for B_l from thermal stability: .1 second time scale of alpha band is mapped to 50 s for B_u and to ~ 3 days for B_l .
2. The synchrotron radiation associated with the diffuse emission from the whole sky but concentrated towards galactic plane corresponds to a field strength $\sim .6$ nT. Zeeman splitting for hydrogen 21 cm line from condensing clouds gives fields in 1-2 nT range. In the plane of the galaxy the field is roughly parallel to spiral arms and its strength is 1-1 nT and too weak to correspond to the proposed magnetic umbilic cord. Also the direction of the spiral arm is different from the direction of the required magnetic umbilic cord.
3. The second guess is that the magnetic umbilic cord is orthogonal to the galactic plane. The direction of the galactic North Pole has the right ascension (identifiable as the sidereal time at the meridian of the rotating observer) $RA=12.49$ $\delta = 27.4$ degrees: RA is not too far from 13.30 so that this guess might make sense. Taking into account that the rotation axis of is tilted by 23.5 degrees towards Sun this would mean that the direction of the magnetic umbilic cord is with accuracy of 3 degrees in the plane defined by the orbit of Earth around Sun. Interestingly, the magnetic field associated with the solar wind varies in the range .2 – 80 nT and average value is 6 nT.

According to [E8], galactic center carries a dipole like field with a strength of order 100 nT, not too far from 10-30 nT. Also this field has filament like structures (flux tubes), which might extend to long distances [E8]. The flux tubes of this field should intersect the galactic plane orthogonally. If the strength of the magnetic field inside the flux tubes stays constant rather than varying like dipole field strength, these flux tubes could give rise to the magnetic umbilic cords connecting us directly to the center of the galaxy. Galactic center, perhaps the immense black-hole region there, could be an monstrous brain having galaxy sized central nervous system! That the model for magnetospheric consciousness would generalize to the scale of entire galaxy would conform with the fractality of consciousness.

4. According to [E8], supernova remnants are accompanied by radial filament like structures carrying magnetic field in 1-10 nT and it seems that supernova wind might carry this field around galaxy: very natural if flux tubes carry the field. According to [E6], for individual sources such as supernova remnants like Cas A Minor, the field strength is 10-30 nT. This corresponds to the interval 5.6 to 17 seconds. That the field strength is of the same order of magnitude as the dipole field at the galactic center conforms with the idea about magnetic nervous system of galaxy connecting the center of the galaxy to the stars. This magnetic field would be easy to observe in case of supernovae because super nova explosion has packed magnetic flux tubes to a very dense bundle.

Connections with other effects?

There might be fascinating connections with other strange findings.

1. In Comorosan effect [K145] , [?] the irradiation of a bio-matter with a laser irradiation lasting for a multiple of 5 seconds has anomalous effect on a catalyst action. 5 seconds corresponds to $n = 3$ cyclotron transition for proton in a magnetic field of 10 nT. Comorosan effect occurs also in a non-living matter and suggests that the magnetic umbilic cord serves as a kind of cosmic clock.
2. The strength of the Earth's magnetic field in far-away in the plasma sheet is about 10 nT. Could this cosmic magnetic umbilic cord be connected with the plasma sheet and be in a synchrony with what happens there? Plasma sheet is known to be highly self-organizing structure containing in the velocity distributions of charged particles features like "wings"

and “eyes” [F7]. In [K67] I have proposed that plasma sheet defines the “self model” of magnetospheric brain and is thus in a role analogous to the insula in the human brain. It would rather natural for the cosmic umbilic cord to couple with that part of the magnetospheric brain which corresponds to the highest level in the self hierarchy associated with the magnetic Mother Gaia.

3. Lungs contain magnetic particles giving rise to magnetic field of about 10 nT. The theory of magnetospheric sensory representations inspires the speculation that the moment of physical death is decided by magnetospheric self sending to lungs stopping signal at proton’s cyclotron frequency associated with 10 nT magnetic field.

3.6.6 Dela-Warr Camera

One can ask how the information about the body part is coded into the fields associated with the transversal MEs. The most naïve guess is that the representation is simply a 4-dimensional photograph about body part, that is dynamical hologram, and that the DNA in the cells which express the formation of a given body part contain this kind of representation. The cells in which the genes are expressed could contain this kind of representation serving as a template and biological control command. Thus body part would contain its own image in each of its cells. The time reversal (phase conjugate) of the 4-D hologram would in turn naturally act as a time reversal of the control command and provide a universal mechanism making possible healing and self repair.

Entire hierarchy of representations in various length scales might be involved providing dynamical photographs about the planned evolution or various bio-molecules, subcellular structures, cells, etc... This sounds utterly simplistic but one can ask what else? The representation for the development body structure must be based on very simple and concrete code since the cells building it during morphogenesis are very simple creatures and see only the light telling where to go and what to do!

This naïve guess might have some truth in it as following arguments suggest. In CASYS2001 symposium Peter Marcer [I73] told about the British engineer George DelaWarr built a remote imaging camera in the 1950s. Using only a test object provided from the subject such as a small blood, sputum, or hair sample, this device photographically images the subjects internal conditions at a distance, with a high degree of accuracy.

A unique feature of the DelaWarr system is claimed to be that it is able to detect diseases in the pre-clinical stages prior to detection by conventional techniques such as physical examination, X-ray, CT scan, or Magnetic Resonance Imaging. The photographs taken by DelaWarr camera were treated by Susan Benford by modern image processing techniques and she claims that these photographs contain the information needed to reconstruct three-dimensional holograms. The proposed explanation was that the test object (adjunct) contains a hologrammic representation about the patient.

The functioning DelaWarr camera looks highly mysterious even when one takes seriously the idea that DNA generates holograms of the body parts it codes for. Therefore it is better to introduce the ingredients of the model by making questions.

1. Was the intent of the photographer all that was needed and did other levels levels of the self hierarchy take care of the rest as they do when I make the decision to raise my hand? Could the intent of the photographer have generated a reference wave at some very special frequency acting on the adjunct and activating a hologram giving rise to a photograph about the desired body part or inducing a sequence of events leading eventually to the generation of the photograph?
2. Was the visible light giving rise to the photograph generated in the adjunct? Does the DNA of each cell of body and thus also of the adjunct contain electromagnetic representations for the body parts and are these representations more or less equivalent with holograms? Certainly direct hologrammic images about body parts would provide the simplest manner to realize the field part of the genetic code as proposed.
3. Did the adjunct serve as a relay station (much like thalamus in brain) mediating the information from the patient via magnetic flux tube-ME pairs to the camera projecting it to the

camera as a coherent light generating an ordinary photograph? Was the image realized as a coherent light propagating along the MEs connecting adjunct and patient serving as bridges?

3.7 The Experimental Work Of William Tiller About Intentional Imprinting Of Electronic Devices

William Tiller in Stanford University has carried out impressive experimental work with what he calls intention imprinted electronic devices (IIED), and his results challenge that standard assumption that the intentions of experimenter do not affect the experimental apparatus [J123, J119, J120].

3.7.1 Experimental Arrangement

The goal was to try to imprint a specific intention into a simple, low tech electronic device so as to influence the companion, specific, well-designed, target experiment. The intentional imprinting was attempted in a meditative state. The intentionally imprinted device, IIED, was sent to a laboratory located at distance of about 1500 miles where colleagues had set up the experiment. The device was placed about 6 inches from a continuously running and computer-monitored target experiment and switched on (total electrical power rate was less than 1 microwatt). Over a time period of about 1-4 months the recorded results from the target experiment changed in the directions of the specific intention and the change eventually reached the selected magnitude of the specific intention. Also an identical, but not intention imprinted device was used and the results were compared in order to achieve more objective measurements about the effects of human consciousness on electric devices.

The targets used were purified water, some bio-molecules, and larvae of flies. These targets were either unshielded or shielded from radiation. For the latter purpose they were closed inside a grounded Faraday cage (FC), which screened rather effectively the radiation coming at microwave frequencies whereas for ultra low frequency (ULF) fields the screening is virtually absent (skin depth behaves as $1/\sqrt{\pi\sigma f}$ at low frequencies and $f = 2\pi\sigma$ (in units $\hbar = c = 1$) defines kind of critical frequency above which screening occurs effectively). The targets could be affected by control device (CD) or by identical IIED generating microwave radiation. Radiation was generated either at single frequency (7.3 MHz) or at three frequencies (5.0, 8.0 and 9.3 MHz) [J121].

In the case of purified water the spatial distributions of physical parameters like pH, temperature, and conductivity were measured as a function time. In the case of bio-molecules the possible effect on thermodynamical activity, which measures the thermodynamical energy of single molecule, was measured. In the case of fly larvae the effect on the larval development time was studied. The results from various arrangements were compared with control targets (no FC, no CD, no IIED).

3.7.2 Basic Experimental Findings

The basic experimental results were two-fold. First of all intended effects were achieved. Secondly, the “conditioning” of the laboratory resulted as an unexpected effect and continued even after the removal of the target and IIED.

Direct effects of the intentional action

1. IIED imprinted by intention to increase/decrease the pH of water gradually induced a shift in the pH of purified water to the intended value, increased the in vitro thermodynamic activity of bio-molecules, and a reduction of larval development time.
2. For bio-molecules and larvae four simultaneous side-by-side treatments were tested: i) an unshielded sample, ii) a shielded sample, iii) a shielded sample with an “on” control device, iv) a shielded sample with an “on” IIED. Just the shielding of em radiation affected the thermodynamic activity of the bio-molecules, and just adding less than about 1 microwatt of microwave radiation via control device reduced the thermodynamical activity and lengthened the developmental time. Thus the microwave radiation acted as a stressor having entropic

effect. When the control device was replaced with IIED, the degradation caused by microwave radiation was overcome.

“Conditioning” of the laboratory

Quite unexpected phenomena arose from a repeated conduct of IIED in a given laboratory space. By simply continuing to use IIED in the laboratory space, it became “conditioned in some very fundamental way”. Three signatures heralded the onset of the “conditioning” process.

1. Oscillations of air and water temperature, and of pH and electrical conductivity of water with large amplitudes with the periods of oscillations in 10-100 minute range developed. The amplitudes of pH- and temperature oscillations was $\sim \Delta pH = .1$ pH-unit and $\Delta T \sim 1 - 3$ K units respectively. Even more remarkably, the oscillations were sustained in the locale even after the removal of the IIED suggesting kind of phantom effect analogous to phantom DNA effect. Oscillation amplitude had peaks at the harmonics of fundamental frequency $f_l = 1/T_l$, $T_l = 36.6$ minutes with three lowest harmonics being very clearly visible [J120]. Also $T_l = 51.2$ minutes appears as fundamental period in some experiments. The ratio of these periods is 1.4 and rather near to $\sqrt{2} = 1.41$, which might relate to p-adic length scale hypothesis.
2. When an pH-increasing IIED with intention to increase pH by one unit was turned on in an almost unconditioned space located several hundred feet away from a strongly conditioned space, a well-defined pattern of pH-oscillations in an unconditioned space emerged. This pattern was accompanied by a highly correlated pattern of oscillations in strongly conditioned space. This kind of highly correlated oscillations were not observed in several unconditioned spaces - also located several hundred feet away.
3. The targets were subject to the action of a vertically aligned magnetic field in the range of $10^{-2} - 5 \times 10^{-2}$ Tesla, such that the direction of the field could be reversed. In an unconditioned space the change of the direction of the magnetic field did not affect the pH. In the strongly conditioned space the effect on pH was different for the opposite directions of the applied field and the difference in pH values was about .6 units. One can say, that the target had become sensitive to the effects of external magnetic fields.

3.7.3 Explanation Of The Ph Oscillations In Terms Of The General Model Of Intentional Action

The findings described above support the notion of magnetic body as a mediator of the intentional action, and provide a connection with the general TGD based vision about pre-biotic evolution. The following general model for the effects suggests itself.

Intentional action induces magnetic self-organization of the control device and target

The magnetic body of IIED becomes a part of the intentional agent. Also the magnetic body of the target (purified water, etc...) partially fuses with that of IIED. Even more, the general model for the pre-biotic evolution [K49, K50] suggests that the intentional action mediated via the IIED induced a self-organization of a p-adic hierarchy of topological field quanta of magnetic field in the target system. This kind of hierarchy is associated also with DNA in the TGD based model for the effects of laser radiation on DNA observed by Gariaev [I85]. The generation of magnetic structures in shorter length scales is what one expects the intentional action to generate since intentional “growth” proceeds quite generally from long to short length and time scales.

The simplest candidate for the time scale of oscillations varying in 10-100 minute range is as the time scale associated with the cyclotron frequency of magnetic field quanta responsible for the intentional action. The cyclotron period of proton lies in 10-100 minute range for a magnetic field strength varying in the range of 27.8-278 pT. For $T_l = 36.6$ minute period the field strength would be 75.9 pT. The corresponding magnetic length is 4 mm and near to $L(188) = 3.7$ mm. The harmonics of the fundamental f_l could correspond to the quantized values of the magnetic flux coming as integer multiples of the basic flux with the strength of magnetic field quantized to

integer multiples. Similar quantization of the Z^0 magnetic field strength is assumed in TGD based model of hearing [K95].

Cyclotron oscillations in the magnetic field could induce by some mechanism a periodic flow of protons between the magnetic flux tubes and the atomic space-time sheets of water and in this manner affect pH. pH-fluctuations would in turn induce temperature and conductivity fluctuations as side effects. Both $T_l = 51.2$ min and $T_l = 36.6$ min appear and have ratio very near to $L(k+1)/L(k) = \sqrt{2}$. If this finding is taken at face value, the magnetic flux quanta must be magnetic sheets for which magnetic flux scales as the inverse of the thickness $d = L(k)$ of the flux sheet having constant size in the second transversal dimension.

Scaling law of homeopathy and frequencies of pH-oscillations and microwaves

The experiment involves two frequencies: the ULF frequencies associated with the pH-oscillations and the frequencies associated with the microwaves generated by the control device. Since intentional action compensates for the entropic effect of microwaves, these frequencies should relate to each other and generalized scaling law is an excellent candidate in this respect.

The TGD based model explains and generalizes the scaling law of homeopathy, which states that low and high frequencies having ratio $f_h/f_l = 2 \times 10^{11}$ accompany each other. Cyclotron oscillations with frequency f_l would result when charged particles drop from smaller space-time sheets and liberate the increment of zero point kinetic energy as a radiation with frequency f_h . Also the reverse of this process could occur with generation of negative energy photons at frequencies f_h and f_l . The emission of two photons is needed to guarantee momentum conservation since the momenta of charged particles are so small as compared to photon momenta.

The generalized scaling law predicts

$$f_h/f_l = \Delta E_0/E_c(k_2) ,$$

where $\Delta E_0 = E_0(k_1) - E_0(k_2)$ is the zero point kinetic energy increment when a charged particle drops from the space-time sheet labelled by k_1 to the sheet labelled by k_2 . $E_c(k_2)$ denotes cyclotron frequency at the magnetic flux tube labelled by k_2 .

The factor f_h/f_l varies but does not depend on the mass of the charged particle and by the quantization of the magnetic flux are apart from a numerical factor proportional to the ratio $p_2/p_1 = 2^{k_2-k_1}$ defined by the p-adic primes $p \simeq 2^k$ for the two space-time sheets in question. The scaling law of homeopathy in its basic form and p-adic length scale hypothesis suggest that f_h/f_l is related by a power of two to $f_h/f_l = 2 \times 10^{11} \sim (200/256) \times 2^{38}$ so that one has

$$f_h/f_l = 2 \times 10^{11} = (200/256) \times 2^n ,$$

where the integer n varies.

The generalized scaling law suggests that the frequency of pH oscillations corresponds to f_l . The frequencies of microwaves would correspond to f_h identifiable as the zero point kinetic energy of proton liberated when it drops from space-time sheet generated by the intentionally induced magnetic self-organization.

The mechanism of intentional action

The control device generates microwaves, and the intentional action should compensate the effect of the control device. The model of the intentional action based on the time mirror mechanism (see **Fig.** <http://tgdtheory.fi/appfigures/timemirror.jpg> or **Fig.** ?? in the appendix of this book) supports the view that negative energy MEs and photons are involved. Phase conjugation means essentially time reversal, and it could compensate the entropic effect of the ordinary microwaves generated by IIED and acting as a stressor in case of fly larvae. This also conforms with the fact that phase conjugate microwaves inside MEs can penetrate the Faraday cage.

The longitudinal Fourier expansion of the fields inside ME contains besides high and low frequency Fourier components and also constant component. The constant component represents intentional action and grows quantum jump by quantum jump to a value realizing gradually the desired effect, say change of pH.

The microwave radiation at frequencies f_h could induce a flow of protons between $k = 167$ space-time sheets and larger space-time sheets by providing the needed zero point kinetic energy to

kick protons to $k = 167$ space-time sheet. Negative energy (phase conjugate) microwave photons would induce the reverse process. By the basic mechanism of induced emission (now induced dropping) this in turn could induce the flow of protons from atomic space-time sheets to smaller space-time sheets as a kind of domino effect, and lead to a new flow equilibrium would result with different pH. The pre-requisite of this mechanism is that the hierarchy of the magnetic flux tubes characterizing also DNA is present in the target. The IIED affected by the intentional action would give rise to this magnetic hierarchy unless it already exists. IIED would play a role similar to an object received by the person to be healed from the healer (or vice versa) in remote healing.

A more detailed space-time description for what happens might be as follows.

1. Constant field representing intention, ULF and microwave fields are coherently superposed inside MEs (incoherence would mean microwave MEs inside ULF MEs) so that the corresponding transversal magnetic and electric fields are precisely parallel by the highly non-linear properties of MEs. ULF frequencies correspond naturally to the harmonics of cyclotron frequency because of the strong coupling to cyclotron phase transitions of the Cooper pair Bose-Einstein condensate.
2. MEs serve as temporary bridges connecting the boundaries of $k = 169$ and $k = 188$ space-time sheets and the oscillating electric field of ME is orthogonal to the boundaries. By quantum classical correspondence the microwave frequencies associated with ME as well as the voltage along the bridge correspond to integer multiples for the energy of a microwave photon. The same mechanism based on Z^0 MEs underlies the TGD based model of nerve pulse.
3. The superposed ULF and microwave frequency electric fields inside ME induce a periodic flow of the protonic Cooper pairs forth and back between the super-conducting flux tubes of the Earth's magnetic field ($k = 169$) and magnetic flux tubes of the field B_I ($k = 188$). Microwave part induces a rapidly oscillating force superposed to the slowly varying ULF part and constant part of the force. The oscillatory flow of protons from atomic space-time sheets to larger space-time sheets affects the proton density at atomic space-time sheets causing pH oscillations.

Do the three peak frequencies for pH-oscillations correspond directly to three microwave frequencies by scaling law?

Scaling law would suggest that the three peak frequencies coming as harmonics of $f = 1/T_l$, $T_l = 51.2$ min, correspond to three frequencies f_l identifiable as cyclotron frequencies corresponding to the quantized values $n = 1, 2, 3$ for the magnetic flux. The frequencies produced by control device producing microwaves in 1-10 MHz range are non-trivial [J119, J120] and the first bet is that the frequencies given by the generalized scaling law must be in this range to compensate the entropic effects. The generalized scaling law $f_h/f_l = (200/256) \times 2^n$ with $n = 33$ gives the frequencies $f_h = 3.1$ MHz and its two harmonics 6.2 MHz and 9.3 MHz as counterparts of f_l and its harmonics. The frequencies produced by the control device are 5.0, 8.0 and 9.3 MHz and not harmonics of each other. Note however that the highest frequency corresponds exactly to the third harmonic of f_l .

Rather remarkably, $f_h = 3.1$ MHz corresponds to the zero point kinetic energy of a protonic Cooper pair at $k = 169$ space-time sheet associated with the magnetic flux tubes of the Earth's magnetic field. Thus protonic Cooper pairs could drop from the super-conducting flux tubes of the Earth's magnetic field to the magnetic flux tubes of ~ 76 pT magnetic field having $k = 188$. This in turn would generate a cascade like dropping of protons from the atomic space-time sheet so that pH is changed.

Correlation between pH and temperature oscillations and protonic zero point kinetic energy

In the case of water at temperature $T = 300$ K the amplitudes of oscillations are $\Delta T = 3$ K and $\Delta pH \simeq .1$. If the density of protons satisfies $n = n_0 \exp(-\Delta E/T)$, where ΔE is most naturally the zero point kinetic energy $.4 - .5$ eV of protons at the atomic space-time sheet, one has

$$\Delta pH = \frac{\Delta E}{T} \times \frac{\Delta T}{T} .$$

$\Delta pH = .1$ would require $\Delta E \simeq .3$ eV, which is quite near $.4 - .5$ eV.

The fact that the exponential $\exp(-\Delta E/T)$ happens to be near to the number $n/n_{H_2O} = 10^{-pH}$, gives further support for the idea that the zero point kinetic energy at $k = 137$ space-time sheet determines pH, or more generally, that the densities of various ions are determined by many-sheeted chemistry and by zero point kinetic energies. If this interpretation is correct, $n(137)$ can be identified as the net density of protons including also protons bound to hydrogen atoms. The net density of protons at a given space-time sheet involves a degeneracy of states factor $g(k)$ so that one would have

$$n(137) = \frac{g(137)}{g(169)} \times n(169) ,$$

where $k = 169$ refers to the super-conducting flux tubes of the Earth's magnetic field. p-Adic fractality and p-adic length scale hypothesis imply that $g(k)$ scales as $1/L^3(k)$. This gives $g(169)/g(137) \sim (L(137)/L(169))^3 = 2^{-48} \simeq 4 \times 10^{-15}$.

Sensitivity to the external magnetic field

The effect of the pH values depends on the direction of the external magnetic field B_{ext} . This could be understood if B_{ext} interferes with the magnetic field at some level of magnetic hierarchy induced by the magnetic fields in .1 nT range which mediate the intentional action. pH is changed if the change of the magnetic field at these space-time sheets in the cellular length scale range affects the flow of protons between atomic space-time sheets and larger space-time sheets when .1 nT flux tubes with thickness around $100 \mu m$ are present. This is expected to be the case if the thickness of the flux tubes is affected by the external magnetic field. The flux tubes in a given p-adic length scale could even disappear as a result of destructive or constructive interference.

Concerning the detailed model there are two options.

1. If the magnetic field consists of flux sheets so that one has $B(k) \propto 1/L(k) \propto 2^{-k/2}$. In this case the external field strength corresponds to p-adic length scale $L(k)$ related to the length scale $L(169) \simeq 5 \mu m$ by a scaling of $.5 \times 10^{-2} - 10^{-3}$ the length scale varies between $L(149) = .5$ nm (thickness of the lipid layer of cell membrane) and 25 nm. This option is supported at the level of DNA magnetic hierarchy by the findings of Gariaev about effects of laser light on DNA, and also by the fact that the ratio of $T_l = 51.2$ min and $T_k = 36.6$ min is very near to $\sqrt{2}$. This situation would result if the flux quanta at various p-adic length scales are quite generally obtained by scaling the flux tubes of the Earth's magnetic field in one direction by keeping the flux as constant.
2. If the magnetic field consists of flux tubes ($B(k) \propto 1/L^2(k) \propto 2^{-k}$) $L(k)$ is related to $L(169)$ by a scaling by a factor $.1 - .03$ so that it is in the range $1.6 - .5 \mu m$.

Phantom effect

A further strange finding is that the removal of both IIED and target does not eliminate the temperature oscillations of the air although their amplitude is reduced by a factor of about ten. The phantom effect can be understood if the magnetic flux tubes associated with $k = 188$ magnetic field are present also in the air volume, and are not affected by the removal of IIED and target, so that the oscillatory flow of protons between $k = 169$ and $k = 188$ space-time sheets with cyclotron frequency continues and induces the oscillation of the proton density of air.

The effects on random number generators

Also the computers might be affected by the "conditioning". Tiller has tested also this [J121] and found clear evidence that this indeed occurs. In the experiment the computer produced a sequence of pseudo-random numbers in a conditioned environment with a rate of one random number per minute. Both processes produced one random number, call it n , per minute. First of all 200 bits are generated 100 times every minute.

1. The first process computes the sum of these 200 bits and calculates the average of the 100 sums resulting in this manner. One expects the average result to be $\langle n \rangle = 100$ and maximum result to be $n_{max} = 200$.
2. The second process picks the second one of the 200 random numbers and compute the sum of the hundred numbers picked up during minute. In this case the average result should be $\langle n \rangle = 50$ and maximum $n_{max} = 100$.

The Fourier transformation of the distribution of these random numbers taken with respect to real time was found to display peaks at frequency $f = 1/T$, $T = 113.778$ minutes and at its harmonics. The presence of precise harmonics is not easy to explain if random numbers are in question.

The mechanism producing the peaks could be the same as the one producing pH oscillations. The representation of the resulting random numbers involves sequence of bits and the number of bits depends on the accuracy used. Since maximum is 200 in the first case and 100 hundred in the second case, the storage of the integer parts of these numbers requires 8 bits in the first case and 7 bits in the second case. The most significant bit is often zero. Cyclotron oscillations could induce a flow of protons from atomic space-time sheets to larger space-time sheet also in the computer and in this manner affect (say) the voltage representing the zero bit so that it changes from 0 to 1 when the amplitude of oscillation is maximum and from 1 to 0 when the amplitude is minimum since the sign of the electric field is different in these two cases. This effect tends to widen the distribution of the random numbers and is enough to explain the emergence of Fourier components coming as harmonics of the cyclotron frequency.

This model predicts that the mechanism tends to increase the mean from the expected value. Consider the case when the expected mean is 100 and maximum is 200. Let $p(i)$ be the probability of the i th bit to be 1, 0. p_0 is the probability that the integer part of n is in the interval $(0, 127)$ whereas p_1 the probability of the random number to be in the interval $(127, 200)$. Since the probability distribution for the resulting pseudo-random numbers is Gaussian around mean value $\langle n \rangle = 100$, one has $p_1 > p_0$. Hence the flip $0 \rightarrow 1$ occurs with a higher probability than the reverse process and tends to increase the mean from $\langle n \rangle = 100$.

Of course, the realization of the mechanism depends on the precise representation of the numbers but the general expectation is that mean increases somewhat and harmonics of cyclotron frequency appear in the spectrum.

3.7.4 The Effects Caused By The Quartz Crystal

In some experiments the removal of the target and IIED was followed by the addition of quartz crystal [J121]. The quartz crystal was made of natural quartz (in order to avoid undesired intentional imprinting!) and had height $h = 15.24$ cm and minimum diameter $d = h/2 = 7.62$ cm. The crystal was asymmetric in the vertical direction having apex pointing upwards.

The findings were following.

1. When the crystal was in a vertical direction, its presence sharpened the existing spatial phantom profile for temperature oscillations of air and somewhat amplified it.
2. When the crystal was turned to a horizontal direction, its presence immediately increased the temporal frequency of T-oscillations by a factor slightly larger than two. The spatial profile became first almost flat and the amplitude weakened.

The interpretation of the stimulates several ideas and questions.

Does the spatial profile of T-oscillations correspond to a standing wave resulting as an interference pattern of microwaves?

The spatial profile for the temperature oscillations is measured using spatial resolution $D = h = 15.24$ cm, where h is the height of the quartz crystal. The profile is quasi-periodic with a period of $\lambda = 2D = 2h$. Of course, experiments with a better spatial resolution would be required to deduce reliably the profile but the measurements are consistent with a spatial oscillation having period $\lambda = 2D = 2h$. This kind of profile could result as an interference of two classical microwave beams propagating in two opposite directions and generating a standing wave with wave length $2h$. This

kind of interference pattern is involved with the four-wave interaction producing phase conjugate waves: the interfering waves correspond to the reference beam and a beam opposite to it. The two additional beams correspond to beam and its phase conjugate, either of them generating the other one.

Does the quartz crystal act as an amplifier?

The orientation of the crystal is obviously important. This encourages to think that the incoming signal enters from a vertical direction and is amplified by the quartz crystal so that the vertical dimension determines the resonantly amplified wave lengths. Perhaps magnetic flux tubes of B_I and the Earth's magnetic field B_E are in this direction. It could be that the light-like vacuum current of ME generates positive or negative energy coherent photons with an intensity distribution having maximum in the directions orthogonal to MEs and that the presence of the quartz crystal amplifies the vacuum current inside ME. Alternatively, it could be enough that quartz crystal amplifies the classical fields associated with MEs.

The height h of the quartz crystal is one half of the microwave wavelength. Hence it could act like an absorbing or emitting half wave antenna. The fundamental frequencies associated with the microwaves would correspond to $f_1 = c/2h \simeq 1$ GHz for the vertical crystal and $f_2 = c/2d = 2f_1 \simeq 2$ GHz for the horizontal crystal. For the vertical crystal $\lambda_1 = 2h = 2D = 30.48$ cm would be the wavelength of the spatial profile which conforms with observations. For the horizontal crystal period would be $\lambda_2 = 2d = 15.4$ cm. The observed spatial profile immediately after the turning of the quartz crystal to horizontal position is flat in consistency with this prediction. It should be easy to check out whether the oscillatory pattern is present by improving the resolution.

Are population inverted many-sheeted masers involved?

The frequencies f_1 *resp.* $f_2 = 2f_1$ are rather near to the zero point kinetic energies of a protonic Cooper pair for $k = 153$ *resp.* $k = 152$. In the case of electronic Cooper pairs one has $k = 164$ and 163 (the ratio of proton and electron masses is near to a power of 2: $m_p/m_e \simeq 2^{11}$). Perhaps many-sheeted population inverted micro wave lasers are involved and time mirror mechanism induces dropping of protons to large space-time sheets or the reverse process. $k = 152$ and $k = 153$ correspond to length scales $\sqrt{2} \times L(151)$ and $2 \times L(151)$, where $L(151) = 10$ nm corresponds to the thickness of the cell membrane. The four-wave interaction suggested by the interpretation of the spatial profile would presumably involve many-sheeted laser mechanism at the microscopic level.

Scaling law of homeopathy is satisfied

The approximate doubling of the ULF frequency of T-oscillations when the quartz crystal is turned to a horizontal position is consistent with the generalized scaling law of homeopathy. The ratio f_h/f_l of frequencies of microwave and ULF oscillations occurring at 51.2 min period is 3.1×10^{12} for $f_h = f_1$ and 6.2×10^{12} for $f_h = f_2$. In a good approximation this ratio differs by a factor 2^4 *resp.* 2^5 from $f_h/f_l = 2 \times 10^{11}$.

3.7.5 Relating Tiller's Hypothesis To TGD Framework

Tiller makes the hypothesis that intentional action induces a transition of the system to a new phase in which $U(1)$ gauge group of electromagnetic interactions is extended to $SU(2)$ of electro-weak interactions. In this phase magnetic monopoles would be present besides ordinary charges. Although this proposal sounds rather far-fetched, it has an analog in TGD framework.

Are electro-weak and color symmetries exact for classical gauge fields in living matter?

In TGD $SU(2)_L \times U(1)$ gauge symmetry could be exact at the level of *classical* electro-weak fields above cell length scale since the classical electro-weak fields are indeed long ranged and become important in biological length scales. This predicts exotic phenomena such as charge entanglement made possible by classical W^\pm fields. Also classical color fields unavoidably accompany any classical em field. The color associated with color rotational degrees of the freedom of space-time sheet could

be also important and analogous to rigid body angular momentum. TGD based model of color qualia relies on classical color fields.

Classification of phases of matter by the dimension of CP_2 projection

The proposal of Tiller relates interestingly to the classification of the phases of matter according to the dimension D of the CP_2 projection of the space-time sheet. This classification emerges naturally in the study of the general solutions of field equations when one assumes that absolute minimization of Kähler action - the original interpretation for preferred extremal property - corresponds to second law so that space-time sheets correspond asymptotically to self-organization patterns for which Lorentz four-force representing dissipation vanishes. This property means that covariant divergence of energy momentum tensor vanishes, and in general relativity context this leads to Einstein's equations with cosmological term. $D = 2$ is analogous to a ferromagnetic phase consisting of simple magnetic flux tubes. $D = 3$ is analogous to a critical spin glass phase between magnetized and de-magnetized phases, is possible only in a finite temperature range, is highly complex but organized, and corresponds to the living matter. $D = 4$ corresponds to the chaotic de-magnetized phase and "dead" matter.

The notion of absolute minimization does not make sense in p-adic context unless one manages to reduce it to purely algebraic conditions. Therefore it is better to talk just about preferred extremals of Kähler action and accept as the fact that there are several proposals for what this notion could mean. For instance, one can consider the identification of space-time surface as quaternionic sub-manifold meaning that tangent space of space-time surface can be regarded as quaternionic sub-manifold of complexified octonions defining tangent space of embedding space. One manner to define "quaternionic sub-manifold" is by introducing octonionic representation of embedding space gamma matrices identified as tangent space vectors. It must be also assumed that the tangent space contains a preferred complex (commutative) sub-space at each point and defining an integrable distribution having identification as string world sheet (also slicing of space-time sheet by string world sheets can be considered). Associativity and commutativity would define the basic dynamical principle. A closely related approach is based on so called Hamilton-Jacobi structure [K18] defining also this kind of slicing and the approaches could be equivalent. A further approach is based on the identification of preferred extremal property as quantum criticality [K18].

For $D = 2$ the induced gauge fields are Abelian and both electro-weak and color holonomy groups reduce to $U(1) \times U(1)$. For $D = 3$ electro-weak holonomy group is the electro-weak group itself whereas color holonomy group is $U(2)$ or $SU(3)$. Classical color fields would be essential for the colors as qualia (sounds like a joke at first). $D = 3$ is indeed the minimum dimension of CP_2 projection allowing color vision whereas black-white vision is possible for $D = 2$ as has been found already earlier.

Does intentional action generate wormhole magnetic fields and homological monopoles?

TGD allows pseudo-monopoles (having no meaning in single sheeted space-time) as wormhole throats through which magnetic flux flows between space-time sheets. An extremely small dipole of magnetic charges defined by the wormhole throats at a distance of about CP_2 length is in question. At a given space-time sheet the structure gives rise to a radial magnetic field in the immediate vicinity of the wormhole throat.

The homological magnetic monopoles could be common in condensed matter systems in many-sheeted space-time (note however that also join along boundaries bonds can mediate the magnetic flux between space-time sheets). Magnetic flux tubes in superconductors might well flow to larger space-time sheet via this kind of throats. Also ferromagnets could feed their flux to larger space-time sheets through wormhole contacts. Solar magnetic fields are modelled using this concept in [K111]. The detection of the homological monopoles could be regarded as a direct support for the many-sheeted space-time, for the notion of homological monopole, and thus for the physical reality of the embedding space $H = M_+^4 \times CP_2$. There is quite recent experimental evidence for magnetic pseudo-monopoles [D42] in condensed matter systems suggested also theoretically in [D19]. These monopoles are however monopoles of the Berry phase connection in momentum space so that they need not have anything to do with homological monopoles.

The magnetic self-organization by intentional action could involve creation of wormhole magnetic field consisting of pairs of positive and negative energy magnetic flux quanta: at least this is energetically an optimal mechanism. The flux between the two sheets flows along wormhole contacts acting as effective magnetic monopoles. In [K98] I have proposed that the changes in the qualitative character of EEG in transitions to altered states of consciousness involving emergence or disappearance of EEG bands might relate to the generation or disappearance of wormhole magnetic fields. New bands would emerge when charged particles dropping to the newly emerge magnetic flux tubes drop to ground state by cyclotron radiation in the EEG band in question.

3.7.6 A Model For The Findings Based On Hierarchy Of Large Planck Constants

The hierarchy of Planck constants suggests an improved and conceptually simpler model for intentional imprinting. Basic ideas are however more or less the same as above.

1. The intentional imprinting means that flux tubes connecting the electronic device with mediators magnetic body are formed. The length of these flux tubes corresponds to the cyclotron time scale, which is between 10-100 minute time scale, which gives could idea about the size scale of the layer of the meditator's magnetic body involved.
2. IIED acts on the target by sending microwave photons part of which travel along the flux tubes to the magnetic body of the meditator as dark photons and are reflected back as negative energy phase conjugate photons and travel now to the target where part of them are transformed to negative energy microwave photons and part induces oscillations in time scale defined by the length of flux tube. This explain pH oscillations and their time scales. Negative energy microwave photons in turn have a syntropic effect compensating for the entropic effect of ordinary positive energy microwave photon generated by the control device. This explains the increase of the thermodynamical activity of bio-molecules and the shortening of the development time of larvae. One can say that the system affecting the target is not IIED but the system IIED + meditator's magnetic body.
3. The values of Planck constant involved correspond to the ratios of times scales 10 – 100 minutes to the time scales of microwave frequencies 5, 8, 9.3 MHz. Order of magnitude is in the range $r = 3 \times 10^{10} - 5.4 \times 10^{11}$. The scaling law of homeopathy claims that $r = 2 \times 10^{11}$ is a preferred value of this ratio.
4. The conditioning of the laboratory can be also understood. In the new unconditioned position the IIED sends microwave photons to the magnetic body of meditator and this sends part of them to the previous target so that synchronized oscillations result. The flux tubes from the magnetic body to the target continue to exist also after the removal of IIED. It is not clear to me whether the effect is present also when IIED is not functioning in the new position. One can of course imagine that the flux tube connection continues to carry large \hbar photons even after the removal of the target and the frequency is determined by the length of flux tube. This would mean that the target would possess a primitive analog of EEG.
5. The action of vertically aligned magnetic field with strength in the range $200B_E - 1000 \times B_E$ could be understood in terms of topological condensation of flux tubes of this field to vertical flux tubes of the magnetic field connecting the target and IIED to the meditator's magnetic body. The wormhole contacts would affect the value of this magnetic field in a way depending on the direction of the magnetic field and also transmit the magnetic noise associated with the flux tubes of this field. Situation could resemble that encountered in the explanation of the correlation between anomalous cognition and sidereal time.
6. The effects on number generators would rely on a similar mechanism. The dark cyclotron frequency associated with the magnetic flux tubes connecting computer to the magnetic body of the meditator and corresponding to a period of 113.778 minutes would induce the deviation from the random behavior. Planck constant would be $\hbar/\hbar_0 \simeq 1.3 \times 10^{10}$ for 5 MHz microwave radiation in this case. The mechanism inducing bit flips could rely on low energy dark photons with large Planck constant but energy above thermal threshold. Dark

frequencies above 10^2 Hz would correspond to ordinary IR frequencies and define photon energies above thermal threshold. The 1 kHz frequency characterizing synchronous firing of neurons might be involved.

3.8 Formation Of Holograms By Time Mirror Mechanism As A Key Mechanism Of Intentional Action?

The findings of Tiller suggest that four-wave interaction [?]r its suitable generalization could provide a basic mechanism of intentional action. In this section this proposal is discussed in detail. The basic statement is that probe and conjugate waves are responsible for the remote metabolism allowing to build the hologram which only in a special case reduces to a standing wave formed by reference beams. In general case the hologram corresponds to a synchronously oscillating field pattern, say an “energy eigen state” of a super-conducting order parameter or plasma wave pattern at plasma resonance frequency.

3.8.1 Four-Wave Interaction As A Mechanism Of Intentional Action

There are however several open questions about four-wave interaction. Could four-wave interaction or its generalization provide a deeper understanding of the scaling law of homeopathy? Could the basic function of probe and conjugate beams be the amplification of the standing wave interference pattern by remote metabolism? Does the standing wave formed by the reference beams serve as a kind of standardized hologram? Is it possible to generalize the notion of hologram in order to get rid of the reference beams?

Are probe and conjugate beams responsible for remote metabolism needed to construct standardized holograms?

The standing wave interference pattern represents a synchronous oscillation of the entire system and would be an excellent physical correlate for the ability of living organisms to act as coherent wholes. The standing wave resulting as the interference pattern of waves propagating in opposite directions would serve kind of a standardized hologram parameterized by the wavelength λ_h . The interference pattern can be also kicked into a motion by Lorentz boost, and the propagation velocity of the interference pattern is an additional characteristic of the pattern.

Probe and phase conjugate beams in four-wave interaction could in turn be interpreted in terms of remote metabolism. System sends negative energy MEs to the geometric past and receives as a response positive energy MEs, and amplification can occur in this process so that negative energy signal serves only a role of control signal. Its generation would utilize the energy provided by the remote metabolism. The emission of negative energy ME would switch on the positive energy laser of the geometric past generating probe beam. The energy source could be system in its geometric past or some system in the environment.

Scaling law and the role of low frequency MEs as inducers of moving standing wave patterns

The degenerate variant of the four-wave interaction does not require low frequency field components. A more general variant involving also them would allow also moving interference patterns so that pattern could represent parameters: f_h and velocity v . This leads to a new interpretation for the scaling law of homeopathy involving the excitations moving with low velocity.

Suppose that the light-like four-momentum vectors of the opposite reference beams are slightly different, such that the frequencies are $f_1 = f_h + f_l$ and $f_2 = f_h - f_l$. In this situation the interference pattern can be regarded as a Lorentz boost of the pattern at rest and thus moves with a finite velocity $v = x/\sqrt{1+x^2}$, $x = f_l/f_h$. If f_l comes as harmonics of a cyclotron frequency, the velocity is quantized for given f_h and coming as powers of 2 if zero point kinetic energy is utilized as metabolic energy.

The simplest realization of the Lorentz boost would be as quantum jump giving a boost to the entire field pattern representing standing wave and somehow the interaction of low frequency

ME with the space-time sheet representing standing wave should realize this boost. The boost would result in the direction of standing wave only if f_l ME has momentum in this direction and the velocity would be $(f_l/f_h)\cos(\theta)$, where θ is the angle between f_h and f_l ME. For the spatial patterns of T-oscillations in air the maximum value of the velocity would be $v = (f_l/f_h)c \simeq 1$ mm/s. For the detected T-oscillations the spatial pattern does not move. The interpretation would be that vertical ULF MEs are in a good approximation orthogonal to the horizontal microwave MEs.

A moving pattern could result also in other ways: in stimulated Brillouin scattering generating also phase conjugate waves, the moving pattern corresponds to classical sound induced in TGD Universe by driving Z^0 ME.

What the interference of reference waves really means?

What the interference of reference beams actually means, is not at all trivial question. TGD allows embedding of standing wave interference patterns as space-time surfaces [?]ut for these field patterns Lorentz 4-force vanishes only modulo effects caused by the classical gravitation so that in a strict sense they do not correspond to asymptotic self-organization patterns.

A less probable possibility is that the interference pattern is not a field pattern at all but a hologram resulting as a response to the presence of two MEs which are spatial mirror images of each other and represent field patterns moving in opposite directions. The force experienced by particles at material space-time sheets could be mediated by wormhole contacts and in a good approximation superposition of forces generated by MEs, and would thus create same effect as genuine standing wave.

3.8.2 Plasma Oscillation Patterns As Generalized Holograms

Standing wave pattern is the quintessence of a hologram. Probably everyone has childhood memories about swinging a rope. Suddenly it requires hardly no effort to keep the oscillation going on and it is difficult to say whether the rope moves or not.

The interference of two reference waves is only one manner to achieve a standing wave pattern and there is no need to stick to the idea that reference beams are necessary to produce the pattern. What is essential is that there is a synchronous spatial oscillation present. A moving standing wave represents kind of elementary hologram: the information content is coded by the wavelength and velocity of propagation for the interference pattern.

One can go however to other extreme and ask how one might achieve maximal representational power. This obviously requires that the frequency of the Fourier components of the wave does not depend on the wave vector at all:

$$f(k) = f_p = \text{constant} . \quad (3.8.1)$$

Plasma oscillations, which correspond to density oscillations of the number density associated with a given ion, have this property. The plasma frequency is given by

$$\omega_p \equiv 2\pi f_p = \sqrt{\frac{q^2 e^2 n}{\epsilon_r m}} , \quad (3.8.2)$$

where n is the number density of ions, q is the charge of the particle using e as a unit, m is its mass, and ϵ_r is the relative permeability. Each ion is characterized by its own plasma frequency.

Examples of plasma oscillations

There is extremely rich palette of plasma oscillations in living matter.

1. Every biologically important ion, such as Ca_{++} , Na_+ , K_+ , Cl_- defines its own plasma frequency. During nerve pulse various plasma frequencies vary but the variation is slow in the time scale defined by the plasma frequency. This would provide a further reason for why ions are so important for the living matter. Also ionosphere and entire magnetosphere contain plasma which supports earlier vision about magnetosphere as a living system.

2. Since atomic nuclei are completely ionized Z^0 ions, every atom and molecule is characterized by a plasma frequency possibly modified by the neutrino screening which can be characterized in terms of Z^0 dielectric constant. Rather remarkably, the Z^0 plasma frequency $f_Z(H_2O)$ of water corresponds to the energy .44 eV, which is the fundamental metabolic energy quantum so that basic metabolism could be related to the formation of holograms defined by Z^0 plasma oscillation patterns of water molecules. Z^0 plasma frequencies are associated also with the electromagnetically neutral matter.
3. Each space-time sheet has its own plasma frequency for every charged particle present at it. Strict p-adic fractality predicts that the densities of the charged particles scale as $n \propto 1/L^3(k) \propto 2^{-3k/2}$ for 3-dimensional structures, which would mean that plasma frequency would scale as

$$\frac{f_p(k)}{f_p(k_0)} = 2^{3(k-k_0)/4} , \quad (3.8.3)$$

so that plasma frequencies would come as 1/4: th octaves. One can consider also structures which are effectively d=1- or d=2-dimensional (say cell membrane). In this case the plasma frequencies would come as

$$\begin{aligned} \frac{f_p(k)}{f_p(k_0)} &= 2^{(k-k_0)/4} \quad \text{for } d = 1 , \\ \frac{f_p(k)}{f_p(k_0)} &= 2^{(k-k_0)/2} \quad \text{for } d = 2 . \end{aligned} \quad (3.8.4)$$

For 1- and 3-dimensional structures plasma frequencies can correspond to zero point kinetic energies coming as powers 2^k if $k - k_0 = n \times 4$ is satisfied so that the preferred p-adic length scales would come as powers of 4. For $d = 2$ the condition is $k - k_0 = 2$. Both lipid layers of cell membrane and cell membrane itself satisfy this condition.

Metabolic synchrony

The condition that plasma frequencies correspond to zero point kinetic energies, quantizes the values of the ion densities for which time mirror mechanism allows to build plasma oscillation patterns. Ionic system becomes “living” only for quantized values of the ion density. This quantization could play a role in bio-control. The variation of neutrino densities responsible for the screening of the Z^0 charge provides one manner to control particle densities.

Ions with charges q_i and masses m_i can utilize the same metabolic source if the ratio of their number densities satisfies the condition

$$n_i = \frac{m_i}{q_i^2} \times n_0 \quad (3.8.5)$$

holds true. For instance, Na_+ and Mg_{++} have $A=22$ so that the condition gives $n(Na_+) = 4n(Mg_{++})$. K_+ and Ca_{++} have $A = 39$ and $A = 40$ so that one would have $n(K_+) = 4 \times \frac{39}{40} \times n(Mg_{++})$.

A more general condition for the metabolic synchrony is that the number densities satisfy the condition

$$n_i = 2^{n_i} \times \frac{m_i}{q_i^2} \times n_0 , \quad (3.8.6)$$

where n_i is an integer. Now the metabolic sources correspond to different space-time sheets.

Since nuclei are completely ionized Z^0 ions and Z^0 charge is in good approximation determined by the neutron number $A - Z$, metabolic synchrony requires in this case

$$n_i \simeq 2^{n_i} \times \frac{A_i}{(A_i - Z_i)^2} \times n_0, \quad (3.8.7)$$

The densities would be in a reasonable approximation inversely proportional to neutron number if same metabolic source is used.

Plasmoids as life forms

The idea about plasma oscillation patterns as generalized holograms and symbolic representations provides a further support to the idea that plasmoids consisting of magnetic flux tube structures plus ions define primitive life forms. The original motivation for the idea came from the notions of magnetic body, universal metabolism based on zero point kinetic energies, and some experimental findings which deserve to be discussed in the recent context.

1. The first strange empirical finding that I learned of was the discovery that the velocity distributions of electrons in the plasma sheet at the night side of the Earth's magnetosphere contained features like "wings" and "eyes" [?] Note however that velocity distributions are in question, and it is not clear how directly they correlate with plasma waves at plasma frequency.
2. Towards the end of the year 2003 came the finding that plasmoids created in laboratory have basic characteristics usually assigned to living systems [?] Plasma oscillation patterns as primitive symbolic representations of external world would be a further characteristic of this kind. Time mirror mechanism (see **Fig.** <http://tgdtheory.fi/appfigures/timemirror.jpg> or **Fig. ??** in the appendix of this book) would also make possible primitive memory and intentional behavior (also plasmoids have magnetic bodies).
3. The findings of Kozyrev [?] have natural explanation terms of phase conjugate waves associated with plasma oscillations at magnetic or Z^0 magnetic flux tube structures of astrophysical size. One certainly cannot over-emphasize the importance the possibility of quantum coherence in astrophysical length scales.
4. The spatial T-oscillation pattern of air discovered by Tiller could correspond to either electromagnetic plasma oscillations of protonic Cooper pairs or to Z^0 plasma oscillations of water.

Protons are favored for obvious reasons. The scaled down electromagnetic plasma frequency for proton Cooper pairs is $f_p = 2^{-3(k-137)/4} \times x \times f_Z(H_2O)$, $x = (3e/2g_Z)$ and $f_Z(H_2O) = 1.45 \times 10^5$ GHz and should be equal to $f_p \simeq 1$ GHz suggested by the properties of the spatial pattern of T-oscillations. This gives $2^{3\Delta k/4} \simeq 10^5$ implying $\Delta k = k - 137 = 22$ with the error of 8 per cent so that the plasma oscillations of proton Cooper pairs should occur at $k = 159$ space-time sheet.

For the Z^0 plasma frequency $f_Z(H_2O) = 1.45 \times 10^5$ GHz of water the scaling $2^{3\Delta k/4} \sim 1.45 \times 10^5$ is required to get $f_p \simeq 1$ GHz. $\Delta k = 23$ gives a correct result with a 7 per cent error. Since $k = 169$ is the space-time sheet at which the nuclei feed most of their Z^0 electric gauge flux, this would give $k = 169 + 23 = 192$ whereas $k = 188 < 192$ is the space-time sheet of magnetic flux tubes supported by Tiller's findings. This option does not look realistic.

5. Crop circles [?] might provide the most fascinating example of plasma wave patterns. Symbolic representations of "sacred geometry" based on rational numbers, some simple algebraic numbers, and π could be in question, and identifiable as an attempt to communicate about the fundamental importance of rational numbers and their extensions defining finite extensions of p-adic numbers concerning the understanding of cognitive consciousness [?]

There are strong indications that the circles are produced by microwaves, and BOLs ("balls of light") have been repeatedly reported in the vicinity of circles [?] Plasmoids would naturally generate the microwaves and the geometry of the crop formation would reflect the geometry of the plasma pattern at some larger space-time sheets. The scale of the smallest microwave patterns is about 15 cm and same as for Tiller's T-oscillation patterns for 2 GHz oscillations.

That the same space-time sheets would be responsible for the smallest crop circle structures and T-oscillation patterns provides support for the general vision. The largest crop formations have a size of about 100 m. $\lambda = 75$ m corresponds to $f = 4$ MHz and $k = 171$ assuming that protonic Cooper pairs are responsible for these structures. The magnetic flux tubes of Earth having $k = 169$ would correspond to $\lambda \sim 27$ m.

In the chapters [?] rather radical proposal, which could have been inspired by Kozyrev's findings besides Chilbolton and Crabwood crop formations [?, ?] that crop circles could correspond to the communications of the descendants of human kind or of highly self-organized magnetic or Z^0 Mother Gaia from the geometric future of Earth.

3.8.3 Nerve Pulse Generation And Holograms

The model for the nerve pulse generation discussed in [?]ssumes that nerve pulse is generated by Z^0 ME connecting the boundaries of space-time sheets and drifting along the axon in such a manner that the effective phase velocity of the Z^0 field pattern is reduced to the nerve pulse velocity. Four-wave mechanism suggest a modification of this mechanism involving interfering Z^0 microwaves acting as reference waves running in opposite axonal directions, and having frequencies differing by twice the frequency characterizing rate of nerve pulses plus transversal probe and conjugate Z^0 MEs containing also the frequencies f_l responsible for remote metabolism.

Is f_l variable or not?

The simplest possibility is that f_l corresponds to a single fundamental frequency and only the angle θ is a variable parameter. The guess $f_l \simeq 1$ kHz promotes itself as the basic frequency of neuronal synchrony and as the time scale for the duration of the nerve pulse. The spatial length per single the nerve pulse in a long axon is about $L = vT_p$, where T_p is the time interval between nerve pulses. Nerve pulses naturally correspond to the maxima of the standing wave so that $\lambda_h = L$ is a natural identification and gives $v = \cos(\theta) \times f_l \lambda_h = \cos(\theta) \times f_l v T_p$ giving $\cos(\theta) = T_l/T_p$ but leaving the value of v free. $v = x \times 10$ m/s and $T = 2$ ms give $f_h = 15/x$ GHz which represents an upper bound for this value of conduction velocity. For this option the angle θ would be the only control parameter and would control both the conduction velocity and frequency of nerve pulses.

It is of course possible that f_l could be varying and expressible as harmonics of some fundamental frequency f_0 . $f_0 = 10$ Hz is the most natural guess since 20 Hz defines the lower bound for audible frequencies and 10 Hz is the alpha frequency beginning to dominate in the absence of sensory input.

Two ways to achieve rate coding

Rate coding could result in two ways.

1. Rate coding could rely on the dependence of the angle $\cos(\theta)$ on the intensity I of the sensory stimulus: the stronger the stimulus the smaller the value of θ . Nerve pulse rate cannot correspond directly to $\Delta f_h = f_l \cos(\theta)$ but would relate to it in a statistical manner like the rate for hopping between the states of bi-stable system relates to the frequency of the driving force in stochastic resonance (for the possible role of the stochastic resonance in nervous system see [?]).
2. If f_l can have also the harmonics of the fundamental frequency as preferred values, as one might expect if cyclotron frequency is in question, the experienced intensity of the stimulus would be constant and change in a stepwise manner every time when the frequency f_l is replaced by its next harmonic. In this case 1 kHz frequency would represent upper bound for f_l . $f_0 = 10$ Hz could define the value of f_l producing no stimulus and $f_l \leq 1$ kHz would correspond to maximal alertness. If various frequencies are in one-one correspondence with memetic code words, 64 frequencies are needed and maximum value would correspond to 650 Hz.

Is the pulse rate quantized?

There is some evidence for the quantization of the experienced stimuli [?] When over-learning occurs in tasks involving temporal discrimination, the memory images about the intensity of sensation as a function of stimulus deviates from smooth logarithmic form in small scales by becoming a piecewise continuous function [?] such that the plateaus where response remains constant are octaves of each other. This suggests that the memory image about the sensation depends only on the 2-adic norm of the 2-adic image of the ratio I/I_0 of the intensity of the stimulus to the threshold stimulus under canonical identification. There are two explanations.

1. For fixed value of θ the integer valued function $\log_2(|I/I_0|_2)$ would correspond directly to the harmonics of the frequency f_l/f_0 determining the rate of nerve pulses,
2. $\cos(\theta)/\cos(\theta_0)$ can have only integer values: geometrically this would mean that the x-axis projection of the allowed points of a unit circle would be integer-valued using $x_0 = \cos(\theta_0)$ as a unit. This option makes sense from the point of view of p-adic physics of cognition.

The identification of the standing wave in the case of nerve pulse

There is a considerable freedom concerning the identification of the standing wave representing nerve pulse hologram and there could be (and probably are) several representations since space-time is indeed many-sheeted. The frequencies involved are below $15/x$ GHz for $v = x \times 10$ m/s if one takes the previous estimate seriously.

Z^0 plasma waves are one possible candidate for the standing waves in question. Using value of Z^0 plasma frequency for water, $x = 1$ gives $\Delta k = 17$ giving $k_{min} = 186 < 188$. If Cooper pairs of protons correspond to the plasma waves, one would have $\Delta k = 16$ and $k_{min} = 153$. The variation range for k is $(k_{min}, k_{min} + 7)$ from the assumption that the range for frequencies f_l is $(7, 10^3)$ Hz.

The order parameters characterizing macroscopic quantum phases are good candidates for quantum holograms. In the case of super conductor the stationary states of the complex order parameter characterizing BE condensation to a given quantum state would define holograms since there is a complete synchrony in the spatial degrees of freedom.

The first variants for the model of nerve pulse were based on the idea that the solitonic Josephson currents associated with the system defined by the Josephson junctions between the lipid layers of the cell membrane could cause the nerve pulse. It became however clear that solitonic Josephson current is too weak for this purpose. One can however consider the possibility that Josephson currents have a representative role. Idealizing the Josephson junctions with a single continuous Josephson junction between the lipid layers, the Sine-Gordon for the phase difference over Josephson junction reads as

$$(\partial_t - qeV)(\partial_t \Phi - qeV) - \nabla^2 \Phi = -m^2 \times \sin(\Phi) . \quad (3.8.8)$$

Here qe is the charge of the super-conducting charge carrier, V denotes the membrane potential ($eV \simeq .05$ eV), and m is a parameter with dimensions of mass and determined by the details of the Josephson junction. V corresponds to membrane potential and is slowly varying.

The right hand side represents a very rapidly oscillating source term, which can be neglected in the lowest approximation and treated as a source term giving rapidly oscillation corrections to the basic lowest order approximation. Since the time scale of oscillations is $T = 2\pi/eV \simeq .8 \times 10^{-13}$ s, the variation of the membrane potential during the nerve pulse can be treated as an adiabatic variation. In the adiabatic approximation $\partial_t \Phi_0 = qeV$ the solutions are standing waves

$$\Phi_0 = qe \int V dt + kz . \quad (3.8.9)$$

Thus the phase factor $\exp(i\Phi) = \exp(i \int eV dt) \exp(ikz)$ represents a standing wave. The wavelength $\lambda = 2\pi/k$ should correspond to the wave length $\lambda = vT$ associated with the nerve pulse.

Intentional action, memory, and holograms

The detailed realization of intentional action at brain level could involve generation of holograms involving synchronous oscillation of the brain region, and gradual quantum jump-by-quantum jump evolution of constant components of electric and magnetic field inside MEs responsible for the control of ion flows between space-time sheets in turn responsible for their concentrations. Standing waves and there moving variants would be one possible manner to realize the holograms.

The negative energy signals to the geometric past would make possible association mechanism in geometric past as a completion of a piece of hologram to a full hologram. Negative energy signal would correspond to only a part of the neural pattern representing the entire memory and would induce in the geometric past the generation of the entire memory mental image communicated back to the geometric future. This would make it un-necessary to do use brain capacity to store associations of past. This could be of utmost importance also for the realization of motor actions: only an incomplete signal to the geometric past would be needed to realize a complex motor action.

3.8.4 Generalized Four-Wave Interaction In Relation To Some Other Anomalies

Four-wave interaction combined with time mirror mechanism might explain many seemingly unrelated anomalies.

1. The standing wave patterns associated with rotating magnetic systems and accompanied by magnetic wall structures [?]ould also be involved with the four-wave interaction and remote metabolism explaining the claimed over unity energy production in these systems.
2. Four-wave interaction could explain Kozyrev's findings about three signals coming from distant astrophysical objects [?] one signal from the future, one from the past, and one effective signal travelling with infinite velocity. The negative energy signal from the geometric future would be accompanied by a positive energy signal from Earth to the object and instantaneous "signal" would correspond to the standing wave representing the interference pattern of reference beams.
3. The phantom effects it Tiller's experiments relate to pH, temperature, and conductivity. One can however ask whether there is any evidence for mechanical phantom effects. The Russian physicist N. A. Kozyrev has indeed demonstrated mechanical "after-effects" caused by the presence of what he calls irreversible process, typically an vibrating torsion pendulum [?]

The experiments of Kozyrev deserve a more detailed discussion. In the experiments with a vibrating torsion balance, the forces at the support points did not disappear even when the vibration had ceased. The effect did not depend on the mass of the body but was dependent on its density. Most significant effects resulted for porous materials. According to Kozyrev: "Also when a system which had been in the vicinity of a periodic process and then brought to a torsion balance, yielded the same effect on it as the process itself... aluminium showed no memory. The largest memorizing effect for processes of both signs has been shown by sugar".

These findings bring in mind poor Donald Duck who once again has run over the verge of the cliff and defies the force of gravity until he realizes how Newtons's laws require him to behave. The second reminiscence is a personal experience. I love swimming and spend long times in sea during summer time. In windy days, completely free floating with empty mind is especially enjoyable. When I return to shore, the experience about being in free floating motion continues for along time after swimming.

The general model for the formation of conscious holograms could explain also the continuation of oscillatory force response in the support points of the torsion pendulum when the oscillation itself has ceased. Every physical system has magnetic body, also the system consisting of torsion pendulum and the support for it. Brain has tendency to entrain to various kinds of oscillations. The entrainment is based on magnetic homeostasis implying that the values of local magnetic fields at some space-time sheets change so that cyclotron frequencies for some ions become equal to the entraining frequency. Same is expected to happen in the case of support system of the torsion

pendulum. Also the well-known tendency of clocks to synchronize could be based on the direct contact of magnetic bodies of these systems and thus be an example of learning in its simplest form.

In the case of Tiller's experiment cyclotron oscillations induce pH-, T-, and σ -oscillations and even oscillations in series of pseudo-random numbers produced by a computer by inducing the flow of protons from magnetic flux tube to larger space-time sheets and back. Forced oscillations for the support of the pendulum induced by cyclotron oscillations of the magnetic body of the support system would be the desired item representing mechanical phenomenon in this list. In Tiller's experiments the oscillations continue when IIED and water sample are removed: in Kozyrev's experiments force oscillations in the support continue after the removal of the pendulum. The reason would be that magnetic body does not react so rapidly as physical body and can preserve the sensory memory hologram about oscillations by utilizing time mirror mechanism and generalized four-wave interaction.

When an object which has been in the vicinity of the oscillating system is brought near to the support system, the oscillatory force appears. This would be the counterpart for the conditioning induced by IIED in Tiller's experiments. The magnetic body of the support system would fuse with the part of the magnetic body of the "learned" system that has become entrained with the oscillations.

One can apply the model inspired by Tiller's observations at quantitative level.

1. Porosity favors the effect. Therefore the entrainment could occur dominantly with the mediation of the acoustic waves created by the oscillating pendulum. The learning is most effective when sound oscillations spend maximal time in the material. The sound waves are indeed caught in pores of the porous material: this is the reason why porous materials are used to absorb sound.
2. Plasma wave holograms at super-conducting space-time sheets are the best candidates for the symbolic representations of the oscillations associated with the support system. A pair (f_h, f_l) of high and low frequencies is involved. In accordance with the scaling law of homeopathy, the ratio of these frequencies defines the velocity of the moving standing wave pattern via the formula $v/c = f_l/f_h$ resulting when the reference waves with frequencies $f_h + f_l$ and $f_h - f_l$ move in opposite directions have frequencies. f_h is the frequency of the probe and conjugate waves making possible to get the energy needed by the formation of the hologram by utilizing time mirror mechanism.
3. In the recent case f_l is naturally the vibration frequency of torsion penduli since the pendulum induces acoustic oscillations with the same frequency f_l and its harmonics. v is sound velocity in the air filling the pores of the material. This fixes f_h completely: $f_h = f_l \times (c/v)$.

f_h must be the plasma frequency f_p of protonic Cooper pairs at some non-atomic space-time sheet of air. The magnetic body might be able to vary the protonic Cooper pair density n in order to tune to the plasma frequency $f_p = (e/\pi)\sqrt{n/m}$ so that it coincides with f_h . The simplest manner for the magnetic body to achieve this is to change the local thickness of the flux tube so that charge density and also magnetic field intensity changes.

f_h must also correspond to a zero point kinetic frequency of some particle so that the oscillations can occur by time mirror mechanism using remote metabolism based on the dropping of particles to larger space-time sheets from some space-time sheet in p-adic length scale hierarchy. Since three conditions must be satisfied, the effect favors certain oscillation frequencies f_l of the pendulum.

In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant h_{eff} so that cyclotron energy would be liberated.

4. A concrete example helps to get some perspective to the problem. For sound velocity $v = 300$ m/s and $f_l = 1$ Hz, one would have $f_h = 1$ MHz and radio wave with wavelength of $\lambda = 300$ m.

The protonic plasma frequency corresponds roughly to p-adic length scale $L(k = 168) \simeq 3.5 \mu\text{m}$, whereas the magnetic flux tubes of the Earth's magnetic field correspond to $k = 169$. It might be that for suitable sizes of pores also the sound resonances inside pores couple to plasma oscillations: this would however require very special conditions to be satisfied. For millimeter sized pores the lowest resonance frequency would be around 3 MHz.

3.9 How To Test The Basic Vision?

In the following some proposals for testing the basic vision are discussed. Possible tests distinguishing between remote viewing and hallucinatory experiences have been already discussed.

3.9.1 Leakage Of Supra Currents As Basic Mechanism

The basic element of the proposed vision is remotely induced leakage of supra currents from magnetic flux tubes to atomic space-time sheets. This same mechanism works for both endogenous biological self-organization and remote mental interactions which would form a routine part of our sensory representations. The most economic experimental strategy would be a direct verification of this basic mechanism.

An especially dramatic effect would be the appearance of ions from magnetic flux tubes to the target of remote mental interaction not present in the target initially. Sue Benford has found evidence for the appearance of S, Mg, and Al in X ray films which were exposed to the radiation coming from so called torsion generator [I161]. Intentional effort was involved with the experiment. What happened was that dots and tracks with typical size scale of one millimeter appeared in the X ray film. The dots and tracks did not allow identification as tracks of charged particles, and the exposed regions contained S, Mg and Al not present elsewhere. The leakage of energetic super-conducting ions to atomic space-time sheets dissipating their energy by emitting electromagnetic radiation and ionizing the atoms is the natural explanation for the effect [I161, I73]. Keith Fredericks has found that similar effect happens in nuclear emulsion when the emulsion is near to finger tips, and interpreted the tracks as tachyons [I145]. Note that both X ray films and nuclear emulsions contain gelatin which is an organic compound and might increase the sensitivity of the system.

3.9.2 Time Reversal For The Leakage Of Supra Currents

The time reversal of the mechanism generating the leakage of supra currents could be especially important for healing. This mechanism is consistent with the presence of remote bound state entanglement and anomalous production of metabolic energy when binding energy is liberated.

The mechanism would be accompanied by a mysterious disappearance of marker ions in the tissue, and manifest as time reversed function of various molecular machines certainly detectable. Phase conjugates of (that is time reversed) microwaves at critical frequencies could induce the healing process. For instance, de-differentiation of cells might be induced in this manner.

As explained earlier, geometric time reversal could typically involve generation of anomalous radiation by excitation of atoms or molecules by emission of negative energy photons. Rotating magnetic systems (Searl machine) would be especially interesting for proving that time reversal indeed occurs. One could try to demonstrate that biological rhythms correspond to dissipation-healing cycles (wake-up sleep period and metabolic cycles being basic examples).

3.9.3 Controlling Metabolism By IR Laser Beams And DNA Functioning By Maser Beams?

One could also test the "dropping" of ions to larger space-time sheets. If the dropping ions have dissipated their energy this means that system acts like a maser at wavelength defined by the reduction of the zero point kinetic energy liberated in the dropping of the ion. The pumping process would correspond to the leakage of the supra currents to atomic or some other space-time sheet, and induced emission to the dropping induced by the photons already present.

In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant \hbar_{eff} so that cyclotron energy would be liberated. In the following only the “dropping” option is discussed.

1. The effectiveness of metabolic energy production in which proton drops and absorbs a negative energy photon of energy about 5 eV could be amplified by a beam of coherent IR light “kicking” protons back to the atomic space-time sheets. The irradiation by phase conjugate beam would “steal” energy from living system by inducing the dropping without locally usable energy. Whether living systems can “steal” energy from other life-forms in this manner could be tested. The “stealing” of the metabolic energy (there is probably a fractal hierarchy of “energy currencies”) from cancer cells by phase conjugate laser light might be the first principle explanation for why Priore’s machine works.
2. The dropping of ions from say $k = 151$ space-time sheet to larger space-time sheets creates microwaves with frequencies corresponding to zero point kinetic energies about $2^{-15}/A$ eV, A atomic number. For electron the energy is about 1/16 eV. These processes could define exotic forms of metabolism, perhaps at the level of DNA. This process could be amplified by an external microwave beam or its phase conjugate and phase conjugate beam could induce the correction of genetic errors.
3. The scaling law of homeopathy [J28] states that high and low frequencies accompany each other and are in a constant ratio for which TGD predicts several values determined as ratios of zero point kinetic energies and cyclotron energies at magnetic flux tubes. The scaling law can be understood as follows: dropping of ions to cyclotron states generates with the zero point kinetic energy and cyclotron photons. Low frequency photons can interact resonantly with the system for which the internal excitations have same low frequency. This generates internal excitation with wavelength which is of the order of system size and this excitation couples resonantly to photons with wavelength equal to system size: thus high frequency photons result.

Thus one might achieve the above proposed effects using also low frequency irradiation. For instance, irradiation by kHz waves in order to achieve generation of bio-photons and irradiation by ELF waves in order to achieve generation of microwave photons. In fact, I started to develop the vision about living system as a macroscopic quantum system from the finding of Blackman [J31] and other pioneers of bio-electromagnetism that ELF radiation has delicate effects in the functioning of living matter. It seems that the basic mechanism might be the dropping of ions between space-time sheets or its time reversal. This mechanism could be tested also for remote objects.

3.9.4 How To Choose Senders And Receivers?

An important aspect of testing is optimal choice of targets and the persons acting as sender.

Quite generally, the optimal target system for demonstrating these effects would be a critical system very sensitive to small perturbations. Any critical system would work, and one might even consider that the critical systems used to detect elementary particles might be used. Overcooled vapor or liquid or overheated liquid is one possibility. One could take register what happens in the system using same methods as in particle physics. Organic compounds might be by definition be this kind of systems.

One could also try to identify optimal “senders”. Persons with strong will power or with firm belief on the effect, or persons with lower level of inhibition (children, actors, artists, ...) could be considered as optimal “senders”. One could find whether some drugs which remove inhibition, could enhance telepathic and psycho-kinetic abilities. The “blessed are the meek since they quantum entangle” prediction could be also tested. Indeed, one of the most dramatic experiments supporting psychokinesis was done using chicken which imprinted to a robot [J113]. The robot, whose behavior was programmed earlier by random number generator, tended to stay near the chicken, as if chicken had induced a quantum jumps changing the geometric past in macro-temporal time scales.

3.9.5 How To Test The Notion Of Conscious Hologram?

The notion of conscious hologram means that practically any part of body can represent any other part of body or even external world. Concerning the notion of conscious hologram at the length scale of body, Kirlian imaging with simultaneous electrical stimulation of other body parts, in particular ear, is very promising manner to test the hypothesis [?]. It is also known that ear forms kind of fractal miniature of body with respect to acupuncture points so that stimulation of particular part of ear electrically creates sensation that particular part of body is stimulated [J108].

PLR spectroscopy [I85] provides a precise and accurate manner to prove the viability of the notion of conscious hologram empirically. What is needed is the analysis of the frequency spectrum: does it really contain the predicted differences of cyclotron harmonics. If this approach and its variants really work it becomes possible to determine experimentally the densities of super-conducting ions and Cooper pairs at parallel space-time sheets.

At the level of remote mental interactions the stimulation of brain electrically could induce in other brain nerve pulse pattern or even experience correlating with the nerve pulse pattern or even experience in the stimulated brain. Even water near criticality could provide this kind of representations. In Imaging laboratory at Hilversum, Holland the following experiment has been performed with success. The experiment involves water droplet near freezing point. A person with abilities of a healer asks for Universe to express something in the structure of the droplet. What results are beautiful fractal patterns representing say plant leaves, even a picture about the laboratory's architecture has been generated in this manner.

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Chapter 4

General Theory of Qualia

4.1 Introduction

Macroscopic quantum phases are an essential element of most quantum theories of consciousness and Topological GeometroDynamics (TGD) is not an exception in this respect. TGD based theory of consciousness relies crucially on the notion of self hierarchy whose geometrical correlate is the hierarchy of space-time sheets realized as a 4-surface in certain 8-dimensional space. The notion of many-sheeted space-time indeed predicts new types of macroscopic quantum phases. This has led to guesses for the quantum correlates of sensory qualia (colors, tastes, odors,..) and conscious thought as various macroscopic quantum phases predicted by TGD but the lack of direct experimental evidence for the macroscopic quantum phases has made more detailed models impossible. The breakthroughs in TGD and TGD inspired theory of consciousness inspired the first trials to construct a general theory qualia. Preliminary and incomplete versions of this theory are published in [?] and in [L1]. During subsequent years the theory got a rather stable shape.

Dark matter hierarchy with levels labelled by the values of a dynamical quantized Planck constant have been the basic theme of the year 2005. TGD inspired theory of consciousness and TGD based view about quantum biology provide perhaps the most fascinating applications for this concept. It must be however added that condensed matter applications, say the models for the anomalous properties of water and for high T_c superconductivity, are of utmost relevance also for TGD based view about living matter. Dark matter hierarchy allows profound insights about the evolution of consciousness and life as the emergence of new levels of dark matter hierarchy, and deepens the view about the anatomy of quantum jump making it also possible to develop a more detailed view about qualia.

The recent progress in the understanding of the hierarchy has led to the discovery of a fractal hierarchy of quantum criticalities whose levels are labelled by the values of $h_{eff} = n \times h$ and understanding of evolution taking place as spontaneous integer scaling of h_{eff} reducing the criticality. This view allows to understand basic aspects of living systems elegantly. Further closely related step of progress relates to the p-adic physics as physics of cognition. The adelic view about space-time and quantum physics allows to understand cognition and imagination as basic aspects of existence also at space-time level. ZEO based view about state function reduction leads automatically to the notion of self as a sequence of state function reductions at the same boundary of CD and death of self as the first reduction to the opposite boundary where time reversed self is generated. Sensory-motor cycle could correspond to the sequence having as basic step the death of sub-self representing sensory mental image and birth of time-reversed sub-self representing motor mental image.

These advances force to modify the original view about qualia. Qualia do not correspond to increments of quantum numbers in quantum jump as state function reduction as believed first. Rather, the flow of quantum numbers between subsystem representing sub-self and environment during the life-time of self representing sensory mental image gives rise to qualia. Typical lifetime of sensory mental image is about .1 seconds. This picture is consistent with the capacitor model of qualia introduced already before explicit formulation of the modified view about qualia. This implies some modifications to the identification of qualia. For instance, in the earlier model visible

colors were identified as increments of quark color quantum numbers of quark color and representable as gluon quantum numbers. In the recent model same color quantum numbers correspond to those for gluons. Furthermore, also color quantum numbers for quarks as such can correspond to visual colors. quantum numbers in the recent picture.

4.1.1 The Notion Of Self And Qualia

The notion of self has been problematic and the recent progress in this respect clarifies also the situation concerning qualia. In ordinary quantum measurement theory repetition of state function reduction leaves the state unchanged. In TGD state function reduction can occur at both boundaries of causal diamond (CD) and in this case the state remains invariant only at the boundary at which the repetition takes place. This allows to understand how the arrow of time and its flow correspond essentially the increase of the average temporal distance between the tips present in the superposition of CDs with second end localized at fixed light-cone boundary. Self can be identified as a sequence of state function reductions occurring at given boundary of CD. The act of free will corresponds to the occurrence of quantum jump to the opposite boundary of CD and changes the arrow of geometric time at the level of the hierarchy of CDs corresponding to self. Qualia must characterize the experiences of self assignable to the repeated state function reductions.

The original model of qualia was based on the idea that all quantum jumps involve change of quantum numbers so that increments of quantum numbers would characterize qualia. This assumption does not make sense for the quantum jumps at the fixed boundary of CD but at the opposite boundary of CD flow of quantum numbers between two subsystems is possible. Hence the increments of quantum numbers or rather the rates for their change would characterize qualia. The capacitor model for sensory receptor, which emerged before the correct view about self, actually assumed this.

One ends up with the following model of qualia.

1. Only the increments of zero modes and quantum numbers are experienced consciously. In the original model these increments were associated with quantum jumps: in the updated model they are associated with a flow of quantum numbers between two sub-systems at the non-fixed boundary of CD.
2. There are geometric qualia corresponding to zero modes expressing the result of quantum measurement in each quantum jump. All geometric information about space-time surface should reduce to geometric qualia. For instance, geometric data given by visual, auditory, and tactile senses should reduce to conscious information about zero modes or about increments of zero modes in quantum jump.
3. A further working hypothesis analogous to functionalism is universality: kinesthetic qualia depending on the quantum number increments are universal. Thus the increments of Poincare and color and electro-weak quantum numbers define what might be called universal kinesthetic qualia.

One can of course consider also the possibility that sensory qualia do not require any quantum number flow to the system corresponding to sub-self and it would be interesting to see whether this idea leads anywhere.

The vision about metabolism as transfer of negentropic entanglement (or rather stealing it from other conscious entities) suggests that the quantum numbers assignable to metabolites correspond to fundamental qualia. At least in the case of biomolecules serving as nutrients this could make sense. Also for olfaction metabolic qualia could be important.

4.1.2 Qualia And Thermodynamics

Thermodynamical approach to qualia suggested itself.

1. The sequence of the states assignable to the changing boundary of CD can be modelled as a statistical ensemble of Fock states, which suggests that thermodynamics is basically part of theory of consciousness. The ensemble of prepared states gives rise to a large number of

statistical qualia. The relationship $dE = TdS - PdV + \mu dN + B \cdot dM \dots$ generalizes to TGD context: note however that in case of ME selves energy is replaced with the Super Virasoro generator L_0 associated with the light cone boundary of ME. Each intensive-extensive variable pair in the differential should correspond to a non-geometric quale, which results only when there is a gradient (flow) of the extensive variable in the direction of the subjective time. Super-canonical thermodynamics should obviously map ordinary thermodynamics to the level of conscious experience.

2. Statistical interpretation also suggests that an averaging over the increments occurs. The possibility of sub-selves makes possible to have sequences of sub-selves (mental images) of finite subjective time duration and this makes possible structured subjective memories (for instance, it becomes possible to remember the digits of a phone number).

The thermodynamical expression for dE suggests a general classification of qualia consistent with the “holy trinity” of existences implied by TGD. Emotions - such as pain and pleasure - can be identified as order-disorder qualia with the sign of the gradient of negentropy associated with negentropic entanglement defining the coloring of emotion. Kinesthetic qualia are associated with generalized forces: senses of force and torque, hearing, and intensity of color sensation would serve as examples. Generalized chemical qualia correspond to flows between two sub-systems for various quantum numbers such as those associated with charged particles, ions, molecules, Cooper pairs, etc. Chemical qualia and color vision would serve as examples. The fermionic generators of super-conformal algebras and states created by them are labeled by binary digits labeling spin like quantum numbers, whose increments could give rise to Boolean consciousness with intrinsic meaning (“This is true”). The flows associated with these binary digits could define Boolean qualia.

The recent formulation of NMP - weak form of NMP - suggests strongly an optimistic analogy of thermodynamical world view. Strong NMP would demand maximum entanglement negentropy gain, and would be in case of dark matter almost deterministic principle. The weak form of NMP allows also reductions in which negentropy gain is not maximal and the negentropy of the final state can also vanish meaning vanishing entanglement entropy [K73]. At first glance TGD Universe looks like a diametrical opposite of the standard Universe. Negentropic entanglement is generated continually and entanglement negentropy increases in statistical sense and life evolves spontaneously and unavoidably. Only the analogs of thermodynamical fluctuations can perturb this trend and imply that TGD Universe is not the best possible one but on the other hand make possible even larger negentropy gains as possible for the strong form of NMP. On the other hand, in standard Universe second law says that ensemble entropy (to be distinguished from entanglement entropy) increases and life is a thermodynamical fluctuation doomed to disappear eventually. Note that second law holds in TGD Universe for processes in which visible matter is not permanently transformed to dark matter.

One can consider the possibility that the thermodynamical relationships could be written by replacing entropy in thermodynamical formulas by entanglement negentropy. The formal structure would remain the same but interpretation would be completely different. Quantum critical systems would be those in which dark matter with large h_{eff} is generated and gives rise to long range quantum fluctuations. An interesting question is whether also thermodynamical criticality could involve generation of large h_{eff} phases [?].

4.1.3 Spectroscopy Of Consciousness

The quantum correlates of sensory qualia suggest what might be called spectroscopy of consciousness. The original working hypothesis was that EEG frequencies correspond directly to various qualia but it seems that this assumption must be replaced with a less restrictive one.

The idea is that EEG (or ZEG, WEG, or GEG) MEs can be assigned with entanglement of a sub-self of magnetic body with sub-self of biological representing various mental images. That sub-selves can entangle with selves remaining themselves unentangled is one aspect of the generalized notion of sub-system and inspired by the hierarchy of space-time sheets allowing to identify the space-time correlate for this kind of entanglement as join along boundaries bonds connecting space-time sheets representing the sub-systems of disjoint space-time sheets. The entanglement in question could be in cyclotron degrees of freedom, charge entanglement, or color entanglement. An

open question is whether this kind of entanglement is possible only for sub-selves characterized by a smaller value of \hbar than self, or always when topologically condensed sub-system is characterized by a smaller value of p-adic prime and separated by a light-like causal horizon from the larger system.

Although EEG and its generalizations seem to serve communication and control purposes rather than representing qualia directly, the notion of spectroscopy of consciousness makes still sense. Furthermore, the identification of the fractal hierarchy of EWEGs and GEGs means a dramatic generalization of this notion making precise quantitative predictions in a huge range of frequency scales resulting by simple scaling from [J44] [K44]. The model allows to assign the frequencies $nf_c \pm f_J$ (f_c is cyclotron frequency and f_J Josephson frequency) with the communications of sensory data to magnetic body and frequencies nf_c with the quantum control performed by the magnetic body. For ordinary EEG the harmonics of cyclotron frequencies of bosonic ions correspond to alpha band and its harmonics assignable to quantum control. Beta and theta bands and their analogs for the harmonics of alpha band correspond to the communication of sensory and cognitive data to the magnetic body. The rough correlations of EEG with the state of consciousness can be understood. The challenge would be to identify detailed EWEG and GEG correlates of sensory experience, emotion, cognition and memory and only the first partially misguided attempts in this direction have been made.

One of the first ideas was a possible connection of the theory of the various magnetic qualia with place and time coding with atomic and nuclear spectroscopy. The correspondence with nuclear spectroscopy is not promising since spin remains invariant in the phase transition to dark matter and if dark matter is at the same temperature as the ordinary matter, spin is thermalized and only cyclotron degrees of freedom are relevant. Spontaneous magnetization could of course change the situation.

Second idea was that the structure of the periodic table could reflect directly itself in the spectroscopy of consciousness. This would mean that various full electronic shells (He, Ne, Ar, Kr, Xe) would correspond to a hierarchy of magnetic qualia relating directly with the band structure of EEG. The periods also seemed to correlate with the five-layered structure of sensory cortex (primary, secondary, etc... areas). The objection against this vision is that biologically important ions must be bosons since only they can form Bose-Einstein condensates. Most of the biologically relevant bosonic ions have cyclotron frequencies in alpha band and this leads to a successful prediction of the band structure and of the narrow resonance bands. The correspondence with the periodic table must be given up unless exotic ions of bosonic atoms (also bosons) are allowed. Exotically ionized bosonic ions (say dark $Ca^{++,\pm}$) are necessary in the model of nerve pulse and result in the charge entanglement by W MEs, which suggests that they are indeed present.

Apart from scaling the spectrum of super-symplectic transition frequencies is constant of Nature if MEs have preferred length scales given by p-adic length scale hypothesis. This leads to powerful predictions and theory is immediately testable. One can indeed identify the basic resonance frequencies associated with EEG as lowest frequencies of this kind. Furthermore, the lower bounds of EEG bands correspond to the fundamental frequencies of super-symplectic transitions assuming p-adic length scale hypothesis. Dark matter hierarchy predicts scaled up variants of these frequencies.

A fascinating possibility is that super-symplectic generators generating the algebra are labelled by zeros of Riemann zeta so that their number is infinite. The generic state would have conformal weight which is linear combination of zeros of zeta. Conformal confinement would hold true and there are two alternatives: the real part of total conformal weight equals to 1/2 or its imaginary part vanishes. The first case could correspond to energy and second case to mass squared as observable. In the first case the number of “energy” qualia would be infinite. Energy metabolism is fundamental and the qualia associated with it could be “energy” qualia.

Also now the representations associated with various p-adic length scales seem to correlate with the hierarchy formed by the areas of the sensory cortex. Recall that p-adic length scale hypothesis and its generalization stating that p-adic primes, which are near but below powers of any prime are favored follows now from NMP and strong form of holography. Strong form of holography allows to realize number theoretical universality in terms of string world sheets and partonic 2-surfaces (briefly 2-surfaces) by continuing them to 4-D preferred extremals and assuming that the parameters characterizing the 2-surfaces belong to an algebraic extension of rationals.

Without exaggeration, spectroscopy of consciousness could be for brain science what atomic

spectroscopy has been for physics and chemistry. It is somewhat astonishing that this possibility has not been noticed before. After all, spectral lines provide extremely effective, reliable and universal way to code information and brain is the most refined information processing system we know. Ironically, brain modellers busily mimicking EEG numerically know that EEG correlates strongly with mental state but do not still notice the enormous information storage potential of EEG spectrum. This is perhaps the most dramatic example of the power of the scientific prejudices (“there is no evidence for the importance of quantum effects in brain length scale”) to hinder seeing the truth staring directly at our face in its full simplicity and beauty. It is also ironic that so many quantum consciousness theorists spend their time by speculating about quantum gravitational Planck length scale basis of consciousness without realizing that spectroscopy is the most important practical outcome of quantum theory and EEG is the most obvious place to search for this kind of spectroscopy.

The appendix of the book gives a summary about basic concepts of TGD with illustrations. Pdf representation of same files serving as a kind of glossary can be found at <http://tgdtheory.fi/tgdglossary.pdf> [L21].

4.2 General Vision About The Quantum Correlates Of Qualia

In this section a general theory providing overall view about the identification of the quantum correlates of qualia is developed. Hard trial and error experimentation with concrete models for the identification of qualia has gradually led to a vision about fundamental physics and general principles behind qualia. Several questions remain still unanswered but it seems that following general vision deserves testing and further development.

1. Qualia can be divided into two classes: discrete, non-geometric, quantal qualia on one hand, and “classical”, geometric or what might be called zero mode qualia on the other hand and measured in the quantum jump. Discrete qualia correspond to quantum jumps defined by the non-diagonal generators of two super algebras. Super Kac-Moody algebra is responsible for the standard elementary particle quantum numbers and the super-symplectic algebra defining the group of isometries for the WCW. Thus quantum measurement theory dealing with the diagonal generators fuses with the theory of non-geometric qualia dealing with the non-diagonal generators.
2. Zero modes can represent various types of geometric information, say position, orientation or more general information about size or shape. Certain subspace of zero modes defines as a coset space a flag-manifold whose points characterize the possible choices of the quantization axes. Flag-manifold coordinates are naturally mapped into magnetic field configurations which in turn determine magnetic transition frequencies. Averages of the increment of the zero modes are experienced but sub-selves make possible to have temporally structured experiences especially important for hearing.
3. Place and time coding is important part of the theory. When EEG frequency (note that there is hierarchy of EEGs and its weak and colored generalizations involved) corresponds to a particular magnetic transition frequency, magnetic transitions in corresponding part of the linear cortical structure occur and induce quantum phase transition waking up mental image giving rise to a sensation that something exist in that particular spatio-temporal position. The sensation about movement of an object of perceptive field and perhaps even the sensation about the rate of time flow result automatically when the mental image moves along the linear spatiotemporal structure.
4. Each quale corresponds to some quantum jump serving as a seed of quantum phase transition for macroscopic quantum phases in quantum critical spin glass state. The assumption that primary sensory organs are the seats of the sensory qualia has turned out to provide the simplest view about sensory experience, imagination, and dreams. Assuming quantum entanglement between sensory organs, brain, and magnetic bodies one can avoid various objections against this scenario. This leaves a lot of room for more detailed identifications. The magnetic transitions for ions in Earth’s magnetic fields are good candidates

for quantum transitions associated with the sensory qualia. Visual colors could correspond to increments of color quantum numbers.

5. Music metaphor in its recent form states that primary sensory organs contain the music (also neurons are probably sensory experiencers but these experiences would not be ours) and nerve pulse patterns and membrane oscillations are the notes. Thus brain would construct symbolic and cognitive representations rather than direct sensory experiences.

EEG MEs would entangle the mental images at magnetic body and in brain and sensory organs. EEG patterns could be also seen as providing a representations for the notes of the music produced by sensory instrument. The function of nerve pulse patterns is to resonantly excite EEG frequencies entangling brain with the magnetic body and to induce magnetic transitions amplified into quantum phase transitions. The frequencies of many of these transitions can be predicted. Essential prerequisite is quantum criticality of the quantum spin glass phases associated with supra phases.

6. The observation that quantum TGD implies quantum measurement theory meant also a breakthrough in the theory of qualia. The localization in so called zero modes is equivalent with the quantum measurement. The cascade of self measurements whose non-deterministic dynamics is governed by Negentropy Maximization Principle [K73] gives rise to the state preparation process leading to a completely unentangled state serving as the initial state of the next quantum jump. Self defines a statistical ensemble as the set of unentangled prepared states resulting in quantum jumps. The statistical description of this ensemble is assumed to provide the description of qualia. It seems that statistical description applies also to the geometric qualia determined by the increments of zero modes. The quantum correlates of the qualia are assumed to correspond very closely to the primary causes of the qualia (for instance, the sensation of force corresponds to the gradient of momentum of some sub-self with respect to subjective time).

Conscious experience is assumed to depend on the increments of zero modes and quantum numbers are assumed to be experienced consciously but to not contain information about the transition to which these increments are associated. One could argue that this is too strong an idealization since quantum jump has complex anatomy and there is also an infinite variety of quantum jump anatomies with no change in quantum numbers.

Qualia can be divided into three basic types: the kinesthetic qualia (determined by increments of Poincare, color and other basic quantum numbers) in quantum jumps; the qualia corresponding to the increments of various kinds of particle numbers (say chemical qualia) and topological quantum numbers; and the entropic qualia relating to information flows associated with the sequence of quantum jumps. The connection with the statistical physics suggests that the average over the increments of the quantum numbers for the sequence of quantum jumps defining the self is experienced consciously. Sequences of sub-selves (mental images) however are experienced separately and this makes possible a temporally structured experience, so that the words of a sentence are experienced separately rather than as an average.

4.2.1 What Qualia Are?

Before going to a detailed model it is useful to pose the question what qualia are. The final answer (as it seems at this moment) to this question provided by the statistical physics analogy has emerged only gradually and in the following this development of ideas is summarized.

Qualia as quantum phase transitions and as discharges of quantum capacitor

In TGD framework the meaning of the primary quale is associated with the mental images created by the self-organization process. If the quale corresponds to an average increment of quantum numbers or zero modes in a long quantum jump sequence, the quantum jump with same increment must occur repeatedly. This picture makes for sub-selves and was inspired by the standard view about state function reduction.

A more recent view inspired by ZEO is that qualia correspond to flows of quantum numbers between two subsystems at the boundaries opposite to the fixed boundary of CD at which state

function reduction does not affect the state. Zero energy state involves actually quantum superposition of these boundaries or equivalently, of CDs with fixed light-cone boundary containing the second boundary. This picture was actually deduced before the realization that self corresponds to sequence of state function reductions at same boundary of CD.

One can imagine at least two mechanism inducing qualia.

1. *Quantum phase transition produce qualia*

Quantum phase transition in which single particle transition occurs coherently for some macroscopic quantum phase produces qualia defined by the increments of quantum numbers in the transition. Quantum phase transition could be induced by the transition frequency: quantum phase transition leading to the generation of new kind of macroscopic quantum phase is in question. Transition frequencies themselves as such serve as symbols initiating this process, much like subprogram call initiates subprogram. They act like the name of dog: when dog hears its own name, dramatic self-organization process is initiated. In ZEO this self-organization process is 4-dimensional. Entire temporal patterns for fields are replaced by new ones in the size scale of CD in the process.

Music metaphor suggests that only the ratios of transition frequency to, say, cyclotron frequency can code for qualia. Only the ratios of Larmor and cyclotron frequencies and Super Virasoro frequencies and the intensities of the Fourier components for various harmonics can affect self-organization process. Furthermore, quale together with its emotional aspects depend on a simultaneous occurrence of several quantum phase transitions induced by the EEG pattern containing several magnetic transition frequencies. For instance, sensation of pain probably involves both the fundamental Super Virasoro transition frequency inducing primary quale and harmonics of this frequency at least partially responsible for the emotional aspects of pain.

2. *Discharge of quantum capacitor produces qualia*

The flow of particles with fixed quantum numbers between “electrodes” of what might be called a quantum capacitor induces qualia defined by the quantum numbers of the particles involved. The “electrodes” carry opposite net quantum numbers. Second electrode corresponds to the sub-self defining the quale mental image. Obviously cell interior and exterior are excellent candidates for the electrodes of the quantum capacitor. Also neuron and postsynaptic neuron. In fact, living matter is full of electrets defining capacitor like structures. The model of sensory receptor as a quantum capacitor will be discussed later. The model applies to various chemical qualia and also to color vision and predicts that also cells should have senses. Ordinary cells would sense only the nearby chemical environment whereas neurons would experience via synapses also representations of external world chemically: at our level of conscious experience these representations could give rise to emotions. The strange behavior of ionic currents leads to the view that even ionic channels and pumps are actually ionic and voltage receptors.

3. *“Final” solution to the problem of qualia*

The TGD inspired theory of qualia [K54] has evolved gradually.

1. The original vision was that qualia and other aspects of consciousness experience are determined by the change of quantum state in the reduction: the increments of quantum numbers would determine qualia. I had not yet realized that repeated state function reduction (Zeno effect) realized in ZEO is central for consciousness. The objection was that qualia change randomly from reduction to reduction.
2. Later I ended up with the vision that the rates for the changes of quantum numbers would determine qualia: this idea was realized in terms of sensory capacitor model in which qualia would correspond to kind of generalized di-electric breakdown feeding to subsystem responsible for quale quantum numbers characterizing the quale. The Occamistic objection is that the model brings in an additional element not present in quantum measurement theory.
3. The view that emerged while writing the critics of IIT of Tononi [K126] is that qualia correspond to the quantum numbers measured in the state function reduction. That in ZEO the qualia remain the same for the entire sequence of repeated state function reductions is not a problem since qualia are associated with sub-self (sub-CD), which can have lifetime

of say about .1 seconds! Only the generalization of standard quantum measurement theory is needed to reduce the qualia to fundamental physics. This for instance supports the conjecture that visual colors correspond to QCD color quantum numbers. This makes sense in TGD framework predicting a scaled variants of QCD type physics even in cellular length scales.

This view implies that the model of sensory receptor based on the generalization of dielectric breakdown is wrong as such since the rate for the transfer of the quantum numbers would not define the quale. A possible modification of the model simple: the analog of dielectric breakdown generates Bose-Einstein condensate and the quantum numbers for the BE condensate give rise to qualia assignable to sub-self.

Non-geometric and geometric qualia

Various types of quantum phase transitions are natural candidates for qualia. In accordance with “Where-What” decomposition of brain information processing, one can decompose qualia into geometric (“Where” and “When”: position, orientation, ...) and non-geometric (“What”: colors, tastes, ...) qualia.

Geometric qualia correspond to the zero modes of WCW in which a localization takes place in each quantum jump. An objection against the notion of geometric qualia is that the choice of the quantization axes changes in each quantum jump and it is not therefore sensible to speak about the change of quantum numbers. For a given change of quantization axes one can however assign to the final state of the quantum jump unique color and spin quantum numbers so that the increment is also unique although the “coordinate frame” can change. Perhaps one should interpret the change of the quantization axes as a discrete quantum version of parallel translation. For the asymptotic states of self-organization the values of the zero modes are expected to approach to the values associated with a maximum of Kähler function so that the choice of the quantization axes becomes stationary.

Non-geometric qualia correspond to non-zero modes and hence to quantum jumps between states of super-symplectic and Super Kac-Moody representations. This suggests that non-geometric sensory qualia can be classified at brain level into super-symplectic qualia and Super-Kac Moody qualia.

1. Super-symplectic qualia are higher level qualia in the sense that quantum jump occurs at the level of the entire WCW rather than at the level of space-time only. The quantum number increments (spin and color quantum numbers) associated with BE-condensing super-symplectic boson characterize the quale. BE-condensation occurs for “WCW photons” rather than ordinary photons whose WCW dependence is characterized by color $SU(3)$ and spin quantum numbers.
2. Magnetic qualia could be much more primitive (perhaps kinesthetic qualia). Endogenous NMR or its generalizations could give rise to entire spectrum of magnetic qualia. Geometric data from external can be coded to zero modes of MEs, in particular the position and other geometric characteristics of sub-self (ME) representing an object of the perceptive field. Most naturally the portion of a magnetic flux tube at which ME is glued to the magnetic flux tube codes the information classically to the properties of ME, especially the light-like vacuum current and classical gauge fields associated with it. Note that this picture leaves open the identification of emotional qualia which seem to something different from sensory qualia.

The entire isometry algebra consists the function algebra of $E^2 \times CP_2$ associated with ME localized with respect to the light-like coordinate of the light-like M_+^4 projection X^3 of the light-like boundary of ME and having well defined conformal weights. This algebra is essentially the function algebra of boundary $X^3 \times CP_2$. Each element of this algebra defines Hamiltonian depending parametrically on the radial coordinate. This algebra must be extended by the CP_2 -localized radial Virasoro algebra of the light-cone boundary to achieve Lorentz invariance. Hamiltonians have conformal weight which is integer valued. Odd integer valued Hamiltonians correspond to non-zero modes whereas even-integer valued Hamiltonians correspond to zero modes. In particular, the Hamiltonians which do not depend on the radial coordinate of the light-cone boundary and have thus vanishing conformal weight correspond to zero modes [K32].

These canonical transformations specify a very general set of choices of quantization axes.

The most general choices of the quantization axes for the canonical $E^2 \times CP_2$ sub-algebra of zero modes are parameterized by the infinite-dimensional flag-manifold defined as the coset space of the canonical group of zero modes and Cartan group of $O(2) \times SU(3)$. Thus the localization in zero modes means also a choice of the quantization axes. Since zero modes characterize macroscopic geometry of the space-time surface, this localization makes the world of the conscious experience classical.

The monomials in the enveloping algebras of the super-symplectic and Super Kac-Moody algebras defined by WCW isometries is the most general candidate for the algebra defining the possible increments of quantum numbers. Primary discrete qualia would correspond to non-diagonal generators of this algebra. Super algebras have decomposition into bosonic and fermionic parts and the first thing coming into mind is that bosonic generators correspond to generalized sensory qualia and fermionic generators to Boolean qualia. This algebra decomposes into zero mode and non-zero mode parts and one should decide which parts give rise to which qualia.

1. The algebra of non-zero modes is obtained by localizing zero mode super-symplectic algebra with respect to the light-like coordinate of the light-like boundary of ME so that the generators are labelled by super-symplectic conformal weight n which does not contribute to mass squared. This supports super-symmetric option: ordinary Lie-algebra generators which act like creation and annihilation operators correspond to complementary pairs of sensory qualia. The pairs of the fermionic generators correspond naturally to Boolean qualia with opposite truth values. The meaning and content of the Boolean statement should be determined by the non-geometric sensory quale associated with the corresponding bosonic generator.
2. Fermionic counterparts of the canonical zero norm generators in zero mode degrees of freedom have zero norm since gamma matrices have vanishing anti-commutators in these degrees of freedom. One might think that also the bosonic generators generate zero norm states. This is however not the case: infinitesimal isometries of the embedding space do not correspond to pure gauge degrees of freedom. This is in fact the property that distinguishes zero mode symmetries from pure gauge transformations.
3. The interaction of super-symplectic algebra states with the classical gauge fields associated with ME induces quantum jumps. In the lowest order of perturbation theory the interaction must be linear in the generators of SCA. As higher order terms of perturbation theory become significant, also transitions generated by the higher powers of Lie-algebra generators occur with a considerable rate and enhance the experienced intensity of the quale and give rise to transitions not possible in the lowest order.

Comparison with ideas of Noe and Regan

Quite generally, discrete non-geometric sensory qualia (such as colors) must correspond to the changes of the quantum numbers in quantum jumps serving as seeds of quantum phase transitions of the quantum critical macroscopic quantum phases combining to form quantum spin glass phase. This allows to interpret the sequence of quantum jumps giving rise to a quale as a process analogous to what we do when we explore room in total darkness or what physicist does when she studies an unknown system by perturbing it slightly again and again and finding the reaction. The “world of classical worlds” character of super-symplectic states corresponds to this idea at the level of physical states.

Lie-algebras mathematize the notion of infinitesimal change (small perturbation) induced by symmetry transformation and thus they are expected to characterize fundamental qualia. The reduction of non-geometric qualia to the representations of Super Kac-Moody and super-symplectic algebras¹, the latter being related to the isometries of WCW of 3-surfaces and acting at the light-like boundaries of MEs, seems indeed possible. What is nice that super generators of the algebra could correspond to Boolean “this is true” qualia in one-one correspondence with sensory qualia.

¹Super-conformal and related super algebras are generalized Lie-algebras introduced in seventies and are encountered in both super string models and TGD.

Poincare algebra is closely related to the Super Kac-Moody algebra. A natural expectation is that the increment of momentum should basically characterize the qualia induced by forces and torques (pressure sense, and sensations caused by ordinary and angular acceleration).

This interpretation is extremely general and implies that quantum TGD and also super Lie-algebra theory at basic level is theory of the fundamental discrete qualia. The unexpected feature is the assignment of qualia to non-diagonal generators rather than diagonal ones as quantum measurement theory would suggest. The notion of quantum jump between quantum histories however provides full support for this interpretation. The realization of the importance of the non-diagonal creation and annihilation operator like generators of Lie-algebra took surprisingly long time although the moment of consciousness is basically nothing but creation of something new and annihilation of something pre-existing. The possibility to understand the special features of color vision, such as the phenomenon of complementary colors and color contrast supports the general idea.

This view is in some aspects consistent with the view represented in the article of Regan and Noe [J106]. The authors do not believe in qualia as properties of the external world and speak about sensory modalities only. To avoid confusions, it is important to make clear that in TGD qualia and sensory modalities are used interchangeably: qualia are not properties of single quantum history but are identified as mental images generated by self-organization processes involving huge number of quantum jumps between quantum histories.

The approach adopted in [J106] relies on experimental data about vision and states that sensory modalities can be characterized, not as properties of the world, but as modes of exploration of the world that is mediated by knowledge of what the authors call sensorimotor contingencies. More concretely, sensory experience can be identified as exploratory activity, much like feeling by fingers what the object of the tactile field is like. The structure of this exploratory activity determines the quale. What happens is that object of external world, or rather, the system consisting of observer and object of the external world, is perturbed slightly in very manner ways and this gives rise to the sensation about shape of object. The study of the responses generated by small perturbations is very much what physicist does when studying unknown physical system. The fact, that is possible to “see” external world by signals by hearing or as vibratory stimulation of skin, supports this view.

For tactile senses and for macro-geometric aspects of all modalities this picture seems to make sense. It is however not at all obvious whether one can realize this vision at macroscopic level in the case of, say, color vision. In TGD framework entire physics reduces to WCW geometry and classically the system representing perceiver and external world corresponds to 3-surface X^3 which can be regarded as a point like object moving in infinite-dimensional WCW. The metaphor for active tactile sensing process could make sense at more abstract level as deduction of the position of system + perceiver 3-surface X^3 in configuration space. This process is deducing the shape of a stone by giving it small kicks. X^3 corresponds in good approximation minimum for the negative of Kähler function and sensory experience is determined by the depth and shape of the bottom of the valley of the spin glass energy landscape. In this self-organization process consisting typically of $N \sim 10^{39}$ kicks per second, the experiences created by kicks would be summed up to average experience giving a conscious view what the surroundings of object look like. This metaphor applies to the sensing of the internal state of observer itself and could involve active perturbation of parts of CNS and receiving of the response.

It is interesting to see how this picture relates to the capacitor model of sensory receptor and to the model of nerve pulse [K96].

1. The capacitor model for sensory receptor assumes that a generalized discharge results as the charge of the other “capacitor plate” changes and crosses the threshold for the occurrence of discharge.
2. In the case of cell membrane a reduction of the magnitude of membrane voltage below criticality would be in question. W ME induces charge entanglement between magnetic body and neuron interior (second plate of the capacitor) and a quantum superposition of states “no nerve pulses” and “nerve pulse”.
3. Magnetic body shares the mental images created in brain via entanglement of sub-selves. From the point of view of magnetic bod the sub-self represented by the entangled state

experience is superposition of “no nerve pulses” and “nerve pulses” states so that conscious experience could in principle involve also the comparison aspect. This comparison aspect could explain why rational entanglement can carry positive information (recall that the p-adic variants of Shannon entropy can be negative). It must be emphasized that the comparison aspect would be due to the sharing of mental images.

4. Multiverse state would be the quantum counterpart of the small perturbation created by the magnetic body curious to get information about the state of biological body by perturbing and comparing. The remote modification of the charge density inside neuron at the “nerve pulse” branch of multiverse could be seen as a (remote) motor action in an abstract sense. Whether qualia quite generally involve generalized motor action creating multiverse making possible comparison remains an open question.

What about emotions?

What seems essential is that qualia involve meaning. In some cases this meaning is emotionally stronger (pain, pleasure), in some cases it is emotionally weaker (colors): in fact, it would seem that one could permute colors without changing much of the overall emotional meaning (actually colors can be distinguished by the behavior they induce [J116]). It seems that emotions give this meaning.

The previous ideas do not however give a slightest hint about how emotional content of the quale emerges. As a matter of fact, the first guess was that emotions are generalized sensory qualia about the state of body and averaging over sub-selves of sub-selves could explain their single pixel nature and low information content but not the emotional quale itself. This might be part of the story since the neuronal sensory experiences created by nerve pulses at synapses at level of neuronal bodies could determine the emotions. Also cellular qualia about nearby chemical environment could contribute to emotions. The realization of the connection with statistical physics led to more concrete ideas about how emotional content of conscious experience might emerge.

Second guess is that emotions and also cognitions correspond to sensory qualia of magnetic body and perhaps correspond to higher level of dark matter hierarchy than ordinary sensory qualia. This leads to a rather concrete view about emotions and cognitions as patterns of cyclotron phase transitions induced at the magnetic body by EEG radiation consisting of dark photons. Entire fractal hierarchy of EEGs, ZEGs, WEGs, and GEGs corresponding to photons, Z^0 bosons, W bosons, and gluons and labelled by p-adic length scales and values of the Planck constant is predicted. Charged bosons could correspond in this framework to sensory qualia in the standard sense of the word whereas neutral bosons could correspond to cognitive and emotional qualia.

General classification of qualia inspired by the connection with quantum measurement theory and statistical physics

The connection between qualia and quantum measurement theory and statistical physics was the real breakthrough in the development of ideas. In some sense this finding is not a news: the close connection between pressure sense and temperature sense and thermodynamics is basic facts of psychophysics and quantum measurement theory involves in essential manner consciousness. First of all, millenium had to change before I realized that quantum TGD predicts standard quantum measurement theory. Each quantum jump can be regarded as an ordinary quantum measurement involving a localization in zero modes representing geometric information following by a state preparation procedure realized as a sequence of self measurements whose dynamics is dictated by Negentropy Maximization Principle (NMP). This suggests strongly the division of qualia to geometric qualia associated with quantum measurement part of quantum jump and non-geometric qualia associated with the state preparation stage.

In TGD framework the contents of consciousness is determined as some kind of average over the sequence of a very large number of quantum jumps defining self. This suggests that qualia allow a statistical description generalizing ordinary thermodynamical ensemble to the ensemble formed by the prepared states in the sequence of quantum jumps after the last “wake-up” of self. This ensemble is dynamical since each quantum jump generates a new member in the ensemble. In standard statistical physics the notion of ensemble is only a fictive concept but in the ensemble defined by self would be the fundamental statistical ensemble realized at the level of subjective

existence. Therefore consciousness theory would provide foundations of both quantum measurement theory and of statistical physics. Before continuing, notice that this picture allows to see the ageing of self with respect to subjective time as a universal phenomenon resulting from an approach to thermal equilibrium. Getting tired would be only one aspect of the same phenomenon. Also mental images should age and this would correspond to gradual loss of the sharpness of the mental image.

Quite generally, one can divide qualia to the geometric qualia characterized by the increments of the zero modes, to the generalized kinesthetic qualia characterized by the increments of Poincare, color and electro-weak quantum numbers, to the generalized chemical qualia labelled by the increments of various particle numbers, such as the numbers of ions or Cooper pairs in various magnetic states and the topological quantum numbers characterizing the topology of the many-sheeted space-time surface, and to the information theoretic qualia characterized by entropy gradients. Besides the gradients of the state variables with respect to subjective time for the statistical ensemble determined by the quantum jumps, also the values of the state variables themselves contribute to the contents of conscious experience. It would thus seem that the theory of qualia reduces to statistical physics and one can expect rather concrete correspondences between sensory inputs and their quantum correlates. In particular various physical metaphors for conscious experience might find a justification in this approach.

4.2.2 Classification Of Qualia In Thermodynamical Framework

Consider now the general classification of qualia in this conceptual framework.

Do qualia depend on the averages of quantum number increments only?

Functionalism, which has been one of the dominating views in neuroscience, states roughly that the contents of consciousness of system is determined solely by its functional structure. The analog of this hypothesis in TGD framework states that the contents of consciousness are determined completely by the increments of zero modes, quantum numbers and particle numbers in various quantum jumps in context independent manner. This hypothesis has very strong implications and internal consistency requirements make possible to test it. For instance, kinesthetic qualia characterized by the increments of Poincare, color and electro-weak quantum numbers would be universal and would not depend on the system to which they are associated.

1. All quantum phase transitions involve frequency increments. Therefore, if hearing is frequency quale and if energy and frequency increments are equivalent, some kind of auditory sensation should be involved with all sensory experiences. The fact that EEG frequencies cover only a small part of the range of audible frequencies, the weakness for the intensity of this sensation could explain why visual and other experiences do not involve sensation of hearing something. One could also argue that the background noise always present in auditory experience actually corresponds to the contribution from other senses.

Also deaf persons should experience some kind of auditory sensation, kind of background noise, if this view is correct. Interesting question is whether this sensation is present if person is made cortically deaf in an artificial manner. One must of course be very cautious here: it might be that this sensation relates only to the dynamical nature of hearing: several qualia, such as pain, have similar time-like nature.

2. The increments of various quantum numbers in magnetic quantum phase transitions would yield similar sensory experiences, generally kinesthetic experiences.

The connection of the theory of qualia with the statistical physics suggests that self experiences some kind of average over the experiences associated with the quantum jumps of sub-self but self itself at highest dark matter level corresponds to single moment of consciousness. Thus averages of the increments of zero modes and various quantum numbers would dictate the contents of mental images. This would in general mean that the approach to a thermal equilibrium would make conscious experience increasingly diffuse when sub-self (mental image) ages unless sub-self is able to fight against second law. Macro-temporal quantum coherence allows to circumvent the

pessimistic conclusion that every mental images in the human time scale of order 1 second consists of about 10^{38} quantum jumps and should be completely fuzzy as a statistical average. Note also that dark matter hierarchy implies hierarchy of average geometric durations of moments of consciousness.

If averages over the increments of zero modes are experienced this implies that kind of a zigzag curve defined by the averages of the increments of the zero modes formed by sub-selves is experienced consciously but not the initial point of this curve. Kind of a principle of relativity at the level of conscious experience would be in question. In fact, it is very difficult to imagine, how zero modes as such could be experienced. For instance, the huge symmetries involved would make it impossible to experience differently symmetry related points. Note that also in physics one can measure only changes of the observables, rather than observables themselves. The fact that conscious observation of visual textures (say lines) is not possible without saccadic motion is consistent with the assumption that only the increments of the zero modes are experienced consciously. The assumption that intersections of the line sight with lines of figure are time coded is consistent with the assumption that short time averages of zero mode increments are coded to sub-selves.

The fact that position and momentum are quantum incompatible qualia seems to be incompatible with the belief that we experience these geometric qualia simultaneously. One could think that it could be possible to circumvent Uncertainty Principle at the level of conscious experience by using the fact that the velocities that we observe are not velocities with respect to geometric time but with respect to subjective time. This is not the case if we experience only the increments of the zero modes which are analogous to momentum variables. The presence of sub-selves each representing some average value of a zero mode increment make it possible to have an idea about continuous path in zero modes which, in accordance with Uncertainty Principle, is however determined apart from a shift in the space of zero modes.

Various types of non-geometric qualia

As found, one can classify qualia into geometric and non-geometric qualia. Geometric qualia correspond to the increments of zero modes expressing the result of quantum measurement in each quantum jump. All geometric information about space-time surface should reduce to geometric qualia. For instance, geometric data given by visual, auditory, and tactile senses should reduce to conscious information increments of zero modes in the quantum jump. Non-geometric qualia correspond to the preparation of state stage of the quantum jump during which zero modes remain constant.

The sequence of the prepared states can be modelled as a statistical ensemble of Fock states, which suggests that thermodynamics, which like quantum measurement theory is a black sheet of fundamental physics, forms basically a part of the theory of consciousness. The ensemble of prepared states gives rise to a large number of statistical qualia. The relationship $dE = TdS - PdV + \mu dN + B \cdot dM \dots$ generalizes to TGD context: note however that in the case of ME selves energy is replaced with the Super Virasoro generator L_0 associated with the light-cone boundary of ME, which for super-symplectic representations need not annihilate the physical states. Each intensive-extensive variable pair in the differential should correspond to a non-geometric quale, which results only when there is gradient (flow) of the extensive variable in the direction of the subjective time. Super-symplectic thermodynamics should obviously map ordinary thermodynamics to the level of conscious experience.

The thermodynamical expression for dE suggests a general classification of qualia consistent with the “holy trinity” of existences implied by TGD.

1. *Emotions as order-disorder qualia*

$T - S$ pair correspond subjective existence and generalizes to disorder-order type, information theoretic qualia about the state of self: hot-cold and pain-pleasure type sensations and also more abstract experiences associated with various sub-selves of self. These qualia are strongly emotional single-pixel holistic qualia measuring whether some kind of an entropy variable is increasing or decreasing. Also zero modes define a statistical ensemble and these geometric emotional qualia might be about external world: perhaps aesthetic experiences and other “non-self-centered” emotions could be in question. The total entropy for the statistical ensemble defined by self de-

termines how sharp the mental image is. Low entropy content means alertness and attentiveness. High entropy content means fuzzy mental image. Getting tired means inability to keep mental images in low entropy state. Fighting against the second law is an essential part in the martial art of having sharp conscious experiences.

2. Kinesthetic qualia defined by generalized forces

p-V pair corresponds to the geometric existence and is replaced with generalized force-generalized coordinate pairs in quantum fluctuating degrees of freedom. The increments of maximum number of mutually commuting Poincare, color and electro-weak quantum numbers define this kind of qualia. The increments of four-momentum code for the sensation of force whereas the increments of orbital angular momentum code for the sensation of torque.

Tactile senses such as pressure sense and their generalizations involve kinesthetic qualia. The increment of energy or equivalently, increment of frequency, can be identified as a correlate for hearing in generalized sense responsible for the essentially dynamical nature of the auditory experience (hearing is time-like version of force sense). Whether spin flip codes something different from torque, and what this something different might be, is not obvious. I

The rate for the increase of the two diagonal color quantum numbers should code intensity type variables associated with color sensation. At least the intensity of color is this kind of variable. The rate for the increase of electric charge of sub-self should code for electric sense possessed by, say, fishes. Also $B - M$, $\phi\rho$ and $E - P$ pairs correspond to generalized forces since electromagnetic fields are reduced to space-time geometry in TGD framework.

3. Generalized chemical qualia

$\mu - N$ pair corresponds to “objective existence” defined by quantum histories with N being generalized to a number of particle like excitations in the Fock state resulting in the state preparation. In this case there must be a flow of particle number in the direction of the subjective time, that is Bose-Einstein condensation type process for, say Cooper pairs. That is the particle number of sub-self increases or decreases. Quite generally, super-symplectic and Super Kac-Moody algebras should define these qualia and the number of these qualia is very large.

1. One can assign particle numbers to super-conducting phases with various magnetic quantum numbers and these could define generalized chemical qualia. They could perhaps be regarded as qualia and subqualia of chemical qualia defined by a particular ion and chemical qualia could actually reduce to magnetic qualia. Since the changes of the magnetic field induce these quantum phase transition, it would seem that magnetic magnetic quantum phase transitions at super-conducting magnetic flux tubes could induce this kind of qualia besides kinesthetic qualia. In principle, endogenous NMR and its generalizations induced by the interaction of magnetic fields of MEs with magnetic magnetic flux tube structures are possible.

Our chemical qualia could correspond to the Bose-Einstein condensation of ions to the super-conducting magnetic flux tubes. The paradigm of four-dimensional brain allows even the possibility that these ions are ions of the tastant or odorant. Also secondary representations at the level of cortex in terms of super-conducting light ions are possible and would give rise to a classification of primary tastes and odors. Magnetic qualia are characterized by definite transition frequencies and this makes possible place (time) coding by magnetic transition frequencies if magnetic field varies along magnetic flux tube (is a function of time). The activation of a point of the living sensory map would generate some quale at that point.

2. For super-symplectic qualia the number of Bose-Einstein condensed possibly colored “WCW photons” having nontrivial dependence on WCW degrees of freedom replaces number of molecules. The condensation rates for the numbers of the configuration space photons with non-vanishing color quantum numbers could be interpreted as correlates of color qualia, whereas the condensation rates for color singlet WCW photons could relate to the intensity of color sensation. If the rates for the transfer of color quantum numbers define intensity type variables associated with the color sensation, then BE condensation to color singlet states does not give rise to experienced quale so that only non-diagonal color generators correspond to visual colors. Also the BE condensation of the ordinary coherent light should give rise to some kind of quale: perhaps vibratory sense which can be developed to effective vision,

could correspond to non-colored vision. Configuration space Hamiltonians are also labelled by 2-dimensional orbital spin quantum number and longitudinal momentum. Polarization sense and sensation about motion of the object of visual field would naturally relate to spin and longitudinal momentum.

3. Tactile senses involve topological phase transitions involving the creation of flux tubes between object and skin whose number would thus be the relevant variable. The purely sensory aspect of physical pain could correspond to a topological phase transition involving the splitting of join-along boundaries bonds between space-time sheets (MEs could even define these bonds) so that N would be now the number of flux tubes. The simplest picture requires that the MEs associated with sensory organs are connected to the MEs responsible for our experience. Of course, splitting and generation of flux tubes could occur also at the level of sensory representations.

4. Boolean qualia

Boolean qualia would be naturally associated with fermion number or fermionic spin degrees of freedom. There are super-symplectic and super-Kac Moody type Boolean qualia. The spin flipping transitions associated with the fermionic generators of super-symplectic algebra might give rise to Boolean consciousness with intrinsic meaning (“This is true/false”).

Fermion number $1/0$ can also represent truth value when wormhole contacts with fermion and anti-fermion at causal horizons of the wormhole contact (having interpretation as partons) are used. The assumption that only fermions/anti-fermions are associated with the “upper” space-time sheet would select automatically a maximal set of independent statements. Boolean statements could be seen as particle-antiparticle pairs living simultaneously at two space-time sheets and one might speak about “Boolean matter”.

In zero energy ontology quantum states are pairs of positive and negative energy states with opposite net quantum numbers. Therefore it is possible to represent Boolean statements in such a way that fermion number represents bit. This also gives rise to a representation of Boolean rule $A \rightarrow B$ as quantum superposition of pairs of Fock states of fermions with individual instances of A and B represented by the states in the Fock basis for fermions. The basic “laws” for this system of rules would be consistent with the conservation laws.

One can argue that the experience of true/false involves always comparison. As proposed, during sharing of mental images the entanglement of two states could also involve comparison which would explain the positive information content of the rational (algebraic) entanglement in p -adic sense. If indeed so, one might think that the conscious experience that statement is true involves a comparison of the statement with a collection of the true reference statements, one half of all possible statements for a given Boolean algebra constructed from N elementary statements and having 2^{N-1} mutually consistent true statements. If true statements are represented as their negation in comparison process based on entanglement, “false” would mean that for one comparison the statement and reference statement area identical and entanglement is not possible and no shared mental image is formed. For “true” the entanglement is possible for all comparisons.

A general model for abstraction process not only explains the basic numbers of the genetic code but also suggests an entire hierarchy of codes [K56] in accordance with fractality of TGD Universe. The next code in the hierarchy is very attractive candidate for “memetic code”. The hypothesis predicts correctly the .1 second time scale for the duration of “our” self (immediate short term memory, duration of psychological moment). Codewords corresponds to sequences of 126 bits with duration of one millisecond: this is indeed the time scale of nerve pulse. The most plausible realization of the codon of the memetic code is in terms of electron’s CD of duration .1 s containing d quark sub-CDs of duration $1/1.28$ ms representing the bits. The frequency of about 10 Hz is in EEG frequency range and also corresponds to ELF topological field quanta with size of Earth representing our cognitive sub-self. Dark matter hierarchy represents a hierarchy of durations of memetic codon coming as $T = rT_0$, $T_0 = .1$ seconds and r is integer valued.

About quantum correlates of alertness and attention

It is a matter of definition whether one can regard alertness, attention, the level of arousal, and other similar attributes of conscious experience as qualia. What is clear that they are not geometric,

sensory or emotional qualia. A possible identification for the quantum correlates of this kind of aspects of conscious experience might be based on the entropy type variables associated with the statistical ensemble defined by self. Thus also entropy rather than only its gradient with subjective time would characterize the conscious experience. Very high/low entropy would obviously mean correlate with diffuse/sharp conscious experience. Obviously macro-temporal quantum coherence would be absolutely essential for having sharp mental images. In this picture alertness would correspond to low entropy state, possibly very few mental images which would have very low entropy. Directing attention to some object of perceptive field could also be regarded as purposeful reduction of the entropy of the sub-self representing the attended mental image. For instance, the diffuse background of my computer screen would correspond to high entropy sub-self and the icon to which I am concentrating my attention corresponds to the low entropy sub-self.

Directing attention to an object of the perceptive field involves amplification type phenomenon and is seen directly as neural activity. This activity would make possible to fight successfully against second law so that the entropy of the attended sub-self would be reduced rather than increase. 7 ± 2 rule might be interpreted as stating that 7 ± 2 is the maximum number of mental images (sub-selves) which can be kept in a low-entropy state simultaneously. Meditative practices often involve concentration of the attention to some object of perceptive field: the number of mental images would be thus minimized to achieve low entropy state of pure alertness. It is interesting to compare the notions of attention and arousal. Arousal wakes-up several mental images. Highly alert state can be even empty of mental images (sub-selves). High level of arousal necessarily involves entropy growth of the mental images by 7 ± 2 rule. One form of attention deficit disorder would involve generation of too many mental images so that mental images necessary become entropic.

Getting tired and fatigue would mean the inability to keep mental images in a low entropy state. The connection with the level of metabolism is thus obvious. One function of sleep might be to “kill” mental images with long wake-up period so that they can reincarnate in a low entropy state. Without this these mental images would become more and more entropic. Sleep would be a fractal phenomenon having counterpart at all time scales: for instance, the wake-up time for sensory mental images would be of order .1 seconds.

4.2.3 Critical Questions And Open Problems

The identification of qualia involves several open questions and the best manner to proceed is to make the unclear aspects of the model as explicit as possible.

Does the brain construct meta-stable sensory maps?

Several highly interesting questions relate to sensory maps. For instance, does brain construct quasi-static sensory maps for the visual world updated continually? The view represented in [J106] is that this need not be the case, and is motivated by several empirical facts, in particular by the observations that there seems to be no visual memory besides the memory of duration of order .1 seconds. It is further argued in [J106] that external world provides the fundamental representation.

Also TGD framework suggests the possibility that the MEs connecting retinas to the object of the perceptive field might be essential for our ability to experience the object of perceptive field as a part of external world. TGD predicts that objects of perceptive field are represented as mind like space-time sheets. Where these mental images are located is a difficult question to answer but the most elegant option is that they reside at the level of sensory organs [K65]. Sensory organs have also magnetic bodies, which can serve as seats for the fundamental sensory representations. Brain would in turn construct symbolic and cognitive representations entangled with these fundamental sensory representations. These representations would entangle with mental images at magnetic bodies associated with various parts of brain so that the resulting structure would have astrophysical size.

If this is the case then the experienced position of the object of perceptive field corresponds to the position of this mind like sheet at the sensory magnetic canvas associated with eyes. Brain would somehow deduce the distances and sizes of the objective of the perceptive field and by back-projection mechanism construct the sensory representation at the level of sensory organs. Remote tactile sensing and the ability to “see” external world by vibratory sense [J106] support

the view that it is orientation-position quale which determines whether an object of perceptive field is experienced as belonging to external world or to body. Also the illusions associated with tactile senses, such as the experienced location of sensation to even dead material object of perceptive field, suggest the same. Perhaps one must make here a careful distinction between sensations about external world on one hand, and about body and body-external world boundary on the other hand.

In TGD view our eyes can be visualized as tubes connecting brain to external world and changing their orientation all the time. Through these tubes light enters to a screen representing visual cortex in a room representing head. Also head is moving and changing its orientation with respect to the external world all the time. The mind like space-time sheets representing objects of perceptive field are certainly present, but they are not static but short-lived objects, having lifetimes not longer than .1 seconds and are recreated all the time and in general in new position of the visual cortex. There is no homunculus inside this room; the experience is not computed nor do 40 Hz EEG waves in some mysterious manner give rise to experience. It is self-organization processes generated by nerve pulse patterns coming from sensory organs and generated by brain itself which give rise to qualia and magnetic transition frequencies serve as names for these processes.

Are super-symplectic qualia associated with vision only?

Super-symplectic qualia are labelled by the increments of color and 2-dimensional spin quantum numbers which for 8-dimensional basic representation correspond naturally to 3+3 basic colors and to polarization sense.

The idea that qualia should correspond very closely to the physical phenomena what qualia suggests that super-symplectic qualia are associated with vision. Light-like 3-surfaces associated with MEs provide indeed classical model for a light front and MEs themselves model geometrical optics in a well-defined sense. MEs inside MEs represent naturally light rays. Also the two-dimensionality of light-like coordinate constant section of the light-like boundary conforms with the two-dimensional nature of the visual experience. In the case of other qualia (except perhaps tactile senses) the two-dimensionality of the objects of the perceptive field is not obvious.

One cannot exclude the possibility that color Lie-algebra, as opposed to higher representations of color group, could correspond to colors, tastes and basic tactile qualia (warm, cold, pain, ..). In the case of odors, and perhaps also in the case of tactile qualia, CP_2 Hamiltonians in higher-dimensional representations of the color group would be needed to account for the large number of these qualia. One could even ask whether some emotional qualia could involve super-symplectic BE condensation type phase transitions or possible phase transition changing the direction of spin polarization of the BE condensate of WCW photons. Although the connection with thermodynamics excludes this possibility, pros and cons of this kind of identification are still worth of a detailed consideration.

1. MEs seem to correspond to the most abstract level in the control hierarchy formed by MEs, super-conducting magnetic flux tubes and ordinary matter. More precisely, super-symplectic states are state functionals in the space of 3-surfaces, “world of classical worlds” and thus correspond to a higher level of abstraction. This would suggest that our qualia should correspond to what happens on the light-like boundaries of MEs. One could however identify super-symplectic-magnetic dichotomy with spirit-flesh dichotomy so that visual experience would represent higher level sense in comparison to other senses.
2. Colors, tastes, odors and tactile qualia like cold, warm and pain allow dichotomic pairs supports the identification as discrete qualia. These good-bad dichotomies are analogous to color-complementary, which supports the view that they could correspond super-symplectic qualia. On the other hand, all sensory qualia can be accompanied by strong entropy gradients explaining positive/negative emotional aspects for qualia such as odors. For reasons of survival organism might even amplify these entropic gradients.
3. One could argue that also emotions could regarded as generalized sensory qualia and the interpretation of pure emotions coming as dichotomic pairs of complementary emotional colors does not exclude the identification in terms of SCA. Emotions involve however often also comparison aspect and this could be reduced to the geometric aspect of the generalized sensory experience represented as a flag-manifold quale representing information about

the space-time surface describing the state of body and CNS geometrically. Therefore, if emotions are accompanied by super-symplectic qualia, they represent pure emotion without any comparison aspect. Does it make sense to speak about, say, pure rage, is difficult philosophical problem.

4. Zero modes involve infinite hierarchy of CP_2 Hamiltonians grouped into representations of color group and odors should correspond to Lie-algebra generators belonging to higher representations of color group instead of octet representation. The simplest vision is that the only difference between colors and, say, odors and tastes is that the Hamiltonians belong to different representations of the color group. The prediction would be that the phenomenon of color contrast and perhaps even color constancy should have counterparts at the level of other qualia. One can argue that this kind of close structural relationship should have been observed if it is really there and tables organizing various sensory qualia neatly to the representations of color group could be found in the text books of neuroscience.
5. One can also wonder why higher representations of color algebra should be experienced so differently from the 8-dimensional representations assumed to be responsible for visual colors. This picture also requires that WCW photons belonging to only single color representation are produced in sensory pathway. It is difficult to imagine a mechanism producing WCW photons belonging to only single color representation unless it is octet representation. One could also argue that only WCW photons in octet representation are produced abundantly and that this is due to the classical color gauge fields accompanying classical electromagnetic fields: if so then higher colors would be rarely realized as conscious qualia.

The assumption that only color octets qualia are possible, allows in principle the identification of colors, tastes and tactile qualia as generalized colors cannot be excluded. Thus a more detailed analysis of this option is motivated.

1. The simplest hypothesis is that 6 basic colors, tastes and basic tactile qualia could all correspond to color flips. This hypothesis is very strong since it suggests that the basic phenomena of color perception such as complementary colors, color contrast, color constancy and possibly even color summation (this phenomenon involves also neural circuitry in essential manner) could have tactile and gustatory counterparts.
2. In the case of tactile senses the very fact that cool resp. warm serves as metaphor for black, blue and green resp. white, yellow and red, encourages the view that tactile qualia correspond to color algebra. In this spirit one could identify the dichotomic pairs cold-warm, pain-pleasant touch and touch-sensation of numbness as counterparts of 3 pairs of color generators of with opposite quantum numbers. Numbness is indeed quale in itself and analogous to sensation of black since it is experienced in absence of sensory input from skin. Proprioception could perhaps be understood as a mixture of sensations of touch and pain-pleasant sensation with geometric qualia. If this view is correct, then superficial touch and pressure sensation are analogous to sensation of color white at different values of brightness.
3. Model predicts six basic tastes. There is evidence for five basic tastes [J89] but situation has not been resolved. Dichotomies suggest that the triplet of bitter, sour and salty corresponds to the triplet of cool colors whereas the sweet, the fifth taste and some sixth taste. One possibility is that different variants of sweet are in question: for instance, sugar and salt and sweet-sour could correspond to different variants of sweet. The sixth taste complementary to bitter could be analogous to color black or sensation of numbness. Very strongly flavored food or bitter food could perhaps induce experience of sixth taste in the same manner as very bright light dazzles.

The basic objection against this kind of assignments is that the tactile and gustatory counterparts of color complementarity and color contrast need not make sense: to my best unprofessional knowledge these phenomena are not observed. One must be however very cautious: these phenomena might be masked by the emotional reactions accompanying these sensations, by the complexity of the phenomena involved and by the non-topographical character of odor and taste perception.

For instance, color contrast phenomenon requires precise object-background separation not possible in the case of odors and tastes. Summation of colors red and green to yellow involves also neural circuitry and does not generalize to the case of tactile senses, tastes and odors.

How qualia are compared?

An interesting question is how geometric qualia are compared consciously. Velocities might be regarded as basic types of qualia for which this kind of comparison occurs. It however seems that velocity type qualia reduce to experience of self about genuine motion of sub-selves inside it if geometric coordinates are mapped to spatial arrays of neurons such that given neuron (or large structure) is sensitive to particular EEG frequency and represents point of map which becomes “alive” when it is activated. Self could also automatically compare the sub-selves representing qualia of same type so that not specific mechanism would be needed. Concerning the comparison of qualia, an interesting idea is that the simultaneous experience of these slightly different qualia gives rise to the simultaneous wake-up of nearby points of the sensory map. This mechanism might be the same as involved with the binaural beat [J30]. This beat mechanism makes it possible, not only to discriminate between slightly different frequencies but also to “hear” very low frequencies not otherwise audible to us. For instance, when one feeds slightly different audible frequencies to ears, difference frequency is heard consciously. Of course, one can argue that this anomalous hearing has nothing to do with comparison in the fundamental sense.

Association problem

How different type qualia are associated with each other? Is spatial and temporal association in the geometric sense always necessary or could it be enough to associate the qualia in subjective time so that they would be associated with same quantum jump and same sub-self always? It would seem that geometric association with same sub-self is the most natural option. Topographical association by the topology of neural circuits is the simplest manner to achieve this and should be involved with vision. The coding of qualia by EEG frequencies is second option. In the case of magnetic transition frequencies continuous spectrum of positions can be coded. Of p-adic lengths define preferred lengths for MEs then the frequency spectrum would be discrete given by integer multiples of basic length: discretization of positional qualia would result if the fundamental frequencies of MEs code for position.

4.3 About The Identification Of The Non-Geometric Qualia

Non-geometric qualia by definition correspond to the quale associated with the state preparation part of quantum jump whereas geometric qualia are understood as characterized by the increments of the zero modes fixed in quantum measurement part of quantum jump. This terminology is somewhat clumsy since one could argue that qualia like pressure and force sense are in a very general sense geometrical.

4.3.1 Color Vision And Super-Symplectic Algebra

Super-symplectic algebra contains infinite number of Hamiltonians in representations of color group and possessing definite two-dimensional spin. For color octet representations, which is the lowest one, there are 3+3 non-diagonal oscillator operator like color generators with opposite quantum numbers. Perhaps the discoverers of color symmetry had some precognition about the possible role of this symmetry when they jokingly choose to call it color symmetry. The 3+3 color generators carrying opposite quantum numbers indeed can be related to the six primary colors forming complementary pairs (with black and white included). This identification, originally stimulated by the observations of mathematician Barbara Shipman [A6] about the dance of honeybee, makes sense.

TGD predicts that classical em field are accompanied by classical long range color fields and super-symplectic representation can give rise to colored states. Of course, quantum jumps of any color system could give rise to color qualia and one cannot even exclude copies of QCD in the length scales of living matter in TGD framework: if this is the case then even the generation of color charged gluons quantum coherently could give rise to color quale. A very strong support for

the correctness of the prediction is that it nicely explains the basic characteristics of color vision (color contrast, color opponency, color constancy) besides reducing the existence of six primary colors to the symmetries of the 8-dimensional embedding space (the structure of which can thus be deduced from the basic properties of color vision!). Perhaps the most realistic interpretation of the higher color representations is as higher level colors. One cannot however exclude the possibility that these representations could act as correlates for other qualia, such as odors and tastes.

Basic facts about color vision

Color space provides a multidimensional representation for different color experiences and satisfying the requirement that colors producing nearly same experience are represented by nearby points of color space. Color circle devised by Newton is the simplest example of color space and provides very economical manner to represent huge amount of information about experience of color (say the fact that blue is more similar to purple than it is to yellow). One can classify colors into spectral colors present in rainbow and non-spectral colors, including many reds, all magentas and most purples and also brown. The famous “inverted spectrum argument” of Locke states that other people might have the same overall set of color experiences as you but differently connected to objects in the external world. For instance, you might experience the colors of rainbow as inverted: your “red” might be my “blue”. This is clearly about possible symmetries of the color space and the very emergence of symmetries is consistent with the idea that qualia correspond at the fundamental level to Lie-algebra generators.

Colors can be represented as composites of primary colors defined as colors which have no other “colorishness” in them: for instance, orange has some yellowishness and redness in it. Red, green, blue and yellow are the primary colors and correspond to diametrically opposite points along the two orthogonal axes of color plane. Complete model of color experience must explain the existence of the primary colors and why some colors are experienced as composite of them. It is clear that the existence of fundamental colors breaks complete color symmetry and leaves only discrete set of symmetries consisting of rotations by multiples of $\pi/2$ and reflections with respect to two color axes and two axes forming angle $\pi/4$ with respect to them. Also these symmetries are broken as detailed study of behavior correlates of color experience has demonstrated [J116]. Color circle is not a complete model of color experience since it leaves out the vast majority of color experiences, including white and black, all their mixtures with each other (grays) and their mixtures with chromatic colors.

One can however generalize color circle to 3-dimensional color space by introducing white-black axis orthogonal to green-red and yellow-blue axis. The three cylindrical coordinates of color space are called hue, saturation and lightness (or brightness). Hue is the azimuthal angle along color circle and corresponds to the basic “color” of surface. Saturation represents the vividness of color experience and corresponds to the perpendicular distance from the central axis for the position of the color experience in color space. For instance, the vivid colors of rainbow lie along the outside edge. All the grays lie along the central axis because they have zero saturation. The “muted”, “muddy” and “pastel” in between have intermediate levels of saturation. The third dimension of surface color is lightness and refers to the height of color’s position. The color circle corresponds to the perimeter of an oblique section through this color solid. This section is oblique because the most saturated yellows are quite light and therefore higher in color spaces whereas the most saturated blues and purples are quite dark and therefore lower in color space.

The phenomena of color constancy, color summation and color contrast are further phenomena related to color vision. Color constancy means that completely homogenous lighting of the visual field by monochromatic light gives rise to no color experiences. This is as it should be since in natural conditions the lighting conditions change all the time. Color summation says that basic colors red, green and blue in suitable proportions sum up to white color. Color contrast means that the region around objects having primary color inherit slight complementary colorishness. For instance, grey object in a red background looks somewhat greenish. The phenomena of color constancy, color contrast and color summation can be satisfactorily understood in terms of experimentally established neural mechanisms [J89]. This does not of course eliminate the need for deeper explanation: the neural mechanisms involved might only reflect the more fundamental facts about color vision.

Can one understand colors Lie-algebraically?

Could one understand these basic facts about color vision in terms of color Lie-algebra? The first question is whether to assign to visual colors the color quantum numbers of states or the color numbers characterizing the changes of states. One could indeed consider the association of three primary chromatic colors and their complementary colors with quark triplet and antiquark triplet, with antitriplet perhaps resulting in tensor product of operation for two triplets. This however implies that color rotation changing the quantization axes should change also the color experience and replace primary colors with new ones: it is however an experimental fact that primary colors are something unique. If they correspond to changes of color quantum numbers induced by specific Lie-algebra generators this is true independently of the particular quantization axes used.

Taking seriously the idea that color Lie-algebra might represent basic facts about color experience, the next question concerns the detailed identification of colors with Lie-algebra generators of color algebra.

1. What seems obvious is that complementary colors must correspond to Lie-algebra generators with opposite sign of quantum numbers. With this assumption 3-dimensional color space could be understood as a space spanned by three diagonal color generators for which there are no linear dependences between color quantum numbers.
2. Primary colors correspond to the six non-diagonal Lie-algebra generators consisting of 3 creation operator like and 3 annihilation operator like generators. There are six primary colors red-green, yellow-blue and white-black.

This leaves only one possibility: the six non-diagonal generators of color algebra correspond to all the primary colors with white and black included. This conclusion came as a little surprise since the identification of white-black pair as associated with spin flips was competing hypothesis.

3. All color pairs are dichotomic pairs providing metaphorical representation for cool-warm dichotomy such that red, yellow and white correspond to warm colors and green, blue and black correspond to cool colors. What could distinguish between white-black pair and non-chromatic colors is color hypercharge: white and black would have vanishing hyper charge. Thus the following identification of quantum number increments (hypercharge and isospin represented as column vector) associated with various colors suggests itself:

$$\begin{aligned}
 \begin{pmatrix} 0 \\ 1 \end{pmatrix} &\leftrightarrow \text{white} & \begin{pmatrix} 0 \\ -1 \end{pmatrix} &\leftrightarrow \text{black} \\
 \begin{pmatrix} 1 \\ 1/2 \end{pmatrix} &\leftrightarrow \text{red} & \begin{pmatrix} -1 \\ -1/2 \end{pmatrix} &\leftrightarrow \text{green} \\
 \begin{pmatrix} 1 \\ -1/2 \end{pmatrix} &\leftrightarrow \text{blue} & \begin{pmatrix} -1 \\ +1/2 \end{pmatrix} &\leftrightarrow \text{yellow}
 \end{aligned} \tag{4.3.1}$$

It seems that one can indeed reduce color opponency, color contrast and color constancy to deeper level in this framework.

1. Opponent process theory of Ewald Hering [J89] explains basic facts about color summation (for example, summation of red and green to yellow which cannot be understood as summation of color quantum numbers). Color opponent processing means that the members of each pair of complementary colors (red, green), (blue, yellow) and (white, black) tend to compete in the sense that receptors give excitatory response for color and inhibitory response for complementary color, or vice versa.

Therefore no sensory experience results for suitably balanced intensities of light for complementary colors. For instance, in the case of red and green the sensation of yellow which represents a wavelength between these two remains as a result of this competition. Color

opponency can be understood as reflecting the competition between quantum jump and its reversal induced by two Lie-algebra generators acting like creation and annihilation operators with same color quantum numbers. Note that the sensation of darkness after closing eyes could correlate with quantum jumps in which the ions or Cooper pairs of macroscopic quantum phase generated by quantum jumps “white” gradually decays back to ground state by quantum jumps “black”. This suggest that same phenomenon should be associated also with other colors. This would mean that immediate after images should tend to have complementary color. Dazzling phenomenon could result from the depletion of the macroscopic quantum phase from which quantum jumps “white” occur.

2. Color contrast is apparently just the opposite of color opponency: region of given color creates the illusion that background has tinge of complementary color. Thus the complementary colors seem to facilitate each other across boundaries whereas inside the boundaries they tend to cancel each. The called double-opponent cells located in the visual cortex can explain at least partially color contrast phenomenon [J89].

A more fundamental explanation is based on the properties of color-charged macroscopic quantum phase and on the properties of the classical color field accompanying ELF em field associated with EEG and inducing the color quantum jumps. Color confinement requires that color charge density of the macroscopic quantum phase formed by exotic super-symplectic representations is such that net color vanishes. Thus a region containing exotic particles with given color quantum numbers would be surrounded by a region of opposite color quantum numbers. Only the second sign for the increment of color quantum numbers is possible for a given colored state of lowest-dimensional representations of color group as one finds easily by studying color triplet and octet representations. Color contrast would thus result from the fact that classical color gauge field does not approach zero sufficiently fast at the boundary of colored region and as a real field necessarily contains with the same intensity the Lie-algebra components stimulating color and its complementary color.

3. Color constancy can be reduced to the phenomenon of color contrast. If the net color charge of a color charged Super Virasoro quantum phase vanishes, there must be also a region of complementary color charge. Since this is not possible for a constant illumination by monochromatic light, no sensory experience results. Color constancy is not absolute law: the exceptional cases could correspond to situations in which the entire perceptive field is not actually perceived and this effectively leads to the situation in which constant illumination covers only part of the visual field. In this case complementary colors should be seen on the boundaries.

The neurology-inspired manner to understand color constancy is that color vision involves comparison in an essential manner. One might say that conscious experience is generated as an integral of the derivative of the intensity of the sensory input such that the initial values at the boundaries of the perceptive field vanishes (this corresponds to the vanishing of the net color charge). If entire perceptive field is illuminated by monochromatic light of constant intensity, there is no sensory experience. A concrete realization of this would be in terms of a saccadic motion. Saccadic motion would translate spatial gradients of the illumination with a given wavelength to increments of color quantum numbers in quantum jump.

4.3.2 Chemical Qualia

Chemical qualia (tastes and odors) are in a well defined sense more primitive than visual qualia. Unless one takes statistical physics connection as an axiom, there are several options concerning the identification of the quantum correlates of chemical qualia.

1. Thermodynamical analogy suggests that basic chemical qualia can be assigned with the Bose-Einstein condensation of super-conducting ions (possibly tastant or odorant), or, less plausibly, to various magnetic transitions of super-conducting ions amplified to macroscopic quantum phase transitions.

2. An alternative identification is in terms of super-symplectic qualia labelled by color and spin quantum numbers. The general objections against assigning other than visual colors and polarization sense to super-symplectic representations have been already discussed.
3. The third option is motivated by the observation that entire hierarchy of experiencers is involved. Thus chemical stimuli, such as odors, could be literally seen at some levels of the self hierarchy. There is indeed empirical evidence for infrared vision based on odor molecules which is however not conscious-to-us.

Quantum correlates of “our” chemical qualia

The naïvest identification of chemical qualia is as correlates of BE condensation of tastants and odorants to the super-conducting space-time magnetic flux tubes. This would predict that the primary chemical sensory experience occurs at the level of sensory organ. The paradigm of four-dimensional brain allows to explain also chemical sensory hallucinations as olfactory memories. The fact that olfactory organs can be regarded as part of brain also supports the view that our primary odor sensation can be localized to primary sensory organ. Quite generally, if super-conducting magnetic flux tube circuits run along sensory pathways to cortex, the events at the level of primary sensory organ can correspond to “our” qualia. This is however not the only option as the following considerations demonstrate.

The energy involved with the BE condensation of single molecule should be extremely small if EEG frequencies are assumed to be able to induce or amplify this process, of order $E = 14$ eV for 10 Hz frequency. If BE condensation occurs by the transfer along flux tubes carrying electric field, this is indeed the case since the BE-condensation energy of BE condensation per molecule is just the change of potential energy when molecule traverses through the join along boundaries bond. It must be emphasized that this kind of mechanism allows also the generation of the BE condensate of ions giving rise to emotion at cortical level. In this case the BE condensation by this mechanism would occur for ions representing large classes of odorants and it would make sense to speak about finite number of chemical qualia. It would not be too surprising if cortex would have developed this kind of classification chemical senses.

Some facts about odors

There are hundreds of receptors for different odorants and this forces to question the idea about primitivity of olfaction. Olfaction is often regarded as the most primitive modality being the only sense involving projections from sensory organs to paleobrain: all other sensory organs project directly via thalamus to cortex. There are two olfactory pathways. The first leads directly to amygdala whereas second leads via the thalamus to cortex as also other sensory pathways. Also entorhinal cortex receives direct projections from olfactory bulb.

Olfactory memories are most emotional and most stable, which is perhaps related with the fact that amygdala which is often regarded as emotional brain, receives direct projections from olfactory bulb but not from other primary sensory organs. The fact that strong odorants are bio-chemically active and induce strong entropy gradients would explain why odors are so emotional. Evolution might have even developed mechanisms amplifying the entropic gradients and thus also emotional responses to odors. The large number of odors is consistent with the idea that each molecule generates its own odor quale in BE condensation on super-conducting magnetic flux tubes. The finite number of odor receptors would not imply that the number of basic odors is finite, but only that there is classification of odors at the cognitive level determining the accuracy of the odor discrimination.

Evidence for infrared vision based on odor molecules?

Callahan has studied the sense of smell of insects [?]. Many insects, such as moths and ants, are known to be attracted by light, say candles and electric lamps and Callahan took as his challenge to understand what is involved. Callahan discovered that insect’s olfaction is not based on chemistry but to a maser like emission of infrared light generated by various molecules such as pheromones, scent molecules and many other bio-molecules. Insects would see rather than sense chemically the sources of the infrared light. The sensillae of the insects serve as receiving antennas and amplify

the incoming maser like infrared emissions. Callahan also observed that the oscillation of insect antennae induce maser like emission from scent/etc. molecules by creating an oscillating emf. Thus sensory experiencing seems to involve active participation from the part of insect. The work of Callahan demonstrates that ELF modulation of IR light is an essential element of the perception mechanism [?].

In the case of insects infrared light emissions from pheromones mediate sexual messages. Pheromones are known to mediate sexual and social signals also in the case of many mammals. For instance, certain chemical messages from female mouse can make male mouse to mate immediately while certain chemical messages from other males make him aggressive. Many mammals, for instance rodents, are known to possess vomeronasal organs, small cigar like sacks containing neurons and having length of order few millimeters [J2], giving rise to an accessory olfactory system, which is known to have much more primitive structure and to work in different way than the ordinary olfactory system. It is also known that this system bypasses cerebral cortex in rodents. There is evidence that even humans have the ability to sniff certain chemicals mediating social and sexual signals without being aware of it and there is already now flourishing perfume industry based on this evidence. The chemicals responsible for sexual attraction are probably pheromones. The fact that pheromones mediate sexual signals in the case of both insects and mammals, is hardly an accident and suggests that the sensory mechanism must be the same and be based on the infrared emissions by pheromones. If the response is at neuronal level and if the cortex is not involved, one could understand why these messages are not experienced consciously. One could test this hypothesis by finding whether coherent infrared radiation at frequencies emitted by pheromones can affect the behavior of higher mammals including humans.

There is a further peculiar coincidence: the cascade of the transduction events occurring in the absorption of photon in retina is repeated in a remarkably similar way in olfactory receptor cells, which respond to odors whereas the receptor cells that respond to sound use a very different system [J2].

Odor perception as IR vision at the level of odor receptors?

The facts described above suggest that also in the case of mammals the experience of odor involves the, possibly un-conscious, detection of infrared light so that humans would not basically differ from insects and that olfactory system has evolved from the receptor neurons sensing infrared light. The proposed identification means that IR odors are like colors and large number of odors means high acuity with respect to the IR wavelength: this is natural if large number of odorants must be distinguished from each other. Furthermore, odor perception at the level of primary sensory organs could involve exotic super-symplectic representations associated p-adic length scales $L(173) = .02$ mm, $L_3(59) = .08$ mm, $L_2(89) = .11$ mm, $L(179) = .16$ mm, $L(181) = .32$ mm and perhaps even shorter length scales corresponding to $k = 167$ and 169 .

If incoming IR photons indeed induce super-symplectic transitions, integer multiples of the fundamental frequency generate maximum response. Good sensory acuity requires that fundamental frequency of the super-symplectic representation is small enough and that the resonant frequencies coded to our conscious experience correspond to relatively high multiples of the fundamental frequency (this conclusion depends crucially on assumption that super-symplectic transition frequencies are multiples of the fundamental frequency). This would suggest that olfactory receptors can perceive consciously very low IR frequencies not conscious-to-us. Similar argument in the case of color vision would suggest that photoreceptors perceive consciously IR frequencies not conscious-to-us. The structures responsible for primary color vision could be cilia containing micro-tubuli with length distribution covering besides visible wavelengths also UV and IR wavelengths. Also in the case of odor perception micro-tubuli are good candidate for the primary detectors of odors: the longest axonal micro-tubuli have length of order .1 mm.

Frequency coding of odors

It is known that odor discrimination relies on spatiotemporal patterns of nerve pulse patterns [J88]. This spike pattern could be however interpreted as coding information about EEG and/or ZEG frequencies which must be excited in order to generate quantum phase transitions generating the sensation of a particular odor which in general involves several primary components. Also geometric

information about, say, the direction of source of odor must be coded into magnetic transition frequencies. A good metaphor is provided by color vision but which much larger number of basic colors and therefore counterparts of cones. The higher harmonics of the transition frequencies might also code emotional reaction to odor discrimination. The importance of ELF modulation in the case of odor perception of insects [?] suggests that this modulation basically codes for the odor experienced by the insect and is thus in the same role as EEG rhythm coding for odor in human brain. The testing of whether infrared light can affect the behavior of mammals would be also a test of TGD based theory of consciousness.

4.3.3 Magnetic Qualia As Generalized Chemical Qualia

Magnetic quantum phase transitions are characterized not only by the increments of the Poincare quantum numbers perhaps giving rise to kinesthetic qualia but also by increments of the particle numbers in various macroscopic quantum phase labelled by magnetic quantum numbers. This would suggest the interpretation as generalized chemical qualia. The BE condensation of particle numbers to given magnetic phase could give rise to a sub-qualia of a chemical quale.

The model for the interaction between sensory organ and its magnetic body [K98] leads to the conclusion that the spatio-temporal patterns of cyclotron phase transitions at the magnetic bodies must be fundamental from the point of view of our consciousness. Varying cyclotron frequencies are ideal for the coding of various perceived geometric variables like frequencies and distances as positions at the magnetic body, and cyclotron frequency patterns generated by biological body would define kind of somatosensory sensations at the level of magnetic body. The representations of the sensory input constructed as temporal sequences of phoneme and note type basic units modulating cyclotron frequencies could be interpreted as cognitive and emotional representations (left brain talks, right brain sings). The chemical qualia of the magnetic body would be cognitive and emotional qualia of ours and correspond to higher level of dark matter hierarchy that our sensory qualia.

Spin flips are problematic since spin does not change in the scaling of \hbar . If magnetic field strength remains invariant and the area of flux quantum scales up as r in the scaling of \hbar , magnetic interaction energy $-\mu \cdot B$ remains invariant whereas cyclotron energy scales up. If dark space-time sheets are at same temperature as ordinary ones, spin would be thermalized and only cyclotron transitions would contribute to qualia. Spontaneous magnetization and spin flips of spontaneously magnetized regions of spin glass having very large magnetic moment might change the situation. One must also remember that the assignment of same temperature to all space-time sheets of the dark matter hierarchy is the most pessimistic working hypothesis.

For instance, magnetic spin flip phase transitions changing the direction of spontaneous magnetization inside figure could induce conscious figure-background splitting. The repeated occurrence of this phase transition and its reversal induced by an oscillating ELF em field would make figure analogous to a twinkling star. This is like superposing to a harmonic background a tone shifted by constant amount so that dissonance distinguishes the superposed tone from background. The Fourier dual of this representation is by phase shift and there is evidence that hippocampal neurons of rat apply this method to represent the position of rat with respect to surroundings as a temporal phase shift of spike patterns with respect to EEG rhythm with hippocampal theta frequency [J32]. Figure-background separation involves decomposition of the perceptive field to objects which means that higher level representation is indeed in question.

Endogenous NMR spectroscopy?

MEs could induce the rotating part of the magnetic field associated with flux tube inducing magnetic transitions. This could make possible an endogenous NMR spectroscopy in which purely magnetic qualia besides force and torque accompanying magnetic transitions would code the points of a living chemical map. Conscious NMR spectroscopy need not however correspond to *our* experiences directly. Rather, it could contribute to proprioception after several averagings implied by the lower position of the cell-sized selves in the self hierarchy. Note however that the BE condensation of coherent photons generated in the magnetic phase transitions on MEs could induce experiences of force and torque at super-symplectic level.

If p-adic length scales define preferred lengths for MEs, then there is a difference between magnetic and super-symplectic transitions. The tunability of the magnetic transition frequencies makes possible the mapping of the geometric information to flag-manifold coordinates mapped to the magnetic transition frequencies mapped to an excitation of certain neuron or neuron group of 4-dimensional brain and thus waking-up the point of cognitive map of the external world or of body.

4.3.4 Kinesthetic Qualia

The connection with statistical physics allows very nice understanding of kinesthetic qualia and tight connections with basic physics.

Are kinesthetic qualia universal?

TGD version of functionalism would state that kinesthetic qualia are completely universal in the sense that the quale is determined completely by the increments of the Poincare, color, and electro-weak quantum numbers in the quantum jumps. Thus both magnetic quantum phase transitions as well as super-symplectic transitions could give rise to similar kinesthetic qualia. Since super-symplectic qualia seem to correspond to higher level qualia in a well-defined sense, there are good motivations to consider the possibility that our kinesthetic qualia correspond to magnetic quantum phase transitions.

The quantum numbers which change in the magnetic quantum phase transitions are spin, orbital angular momentum, momentum in the direction of the magnetic flux tube, and the energy of the single particle state. The kinesthetic qualia associated with the magnetic quantum phase transitions could basically correspond to the experiences of torque in the case of angular momentum increment and force in the case of increment of longitudinal momentum. Also the increment of the integer n characterizing the radial dependence of the harmonic oscillator wave function could give rise to some kind of quale. Kinesthetic interpretation would encourage to assign a sensation of radial force to this kind of transition. Since the eigenvalues of the harmonic oscillator Hamiltonian are integers, one could consider also the possibility that elementary arithmetic quale could be in question. Generalized hearing as time-like force sense seems however to provide the most convincing identification.

Momenta correspond to spatial translations whereas energy corresponds to time translations and in spirit of special relativity one expects that sensation of energy flow is the counterpart of sensation of force. Sense of force involves always some spatial direction and sense of torque direction of rotation besides the intensity of the force of torque. Auditory experience involves duration and direction of time in an essential manner and the increment of energy, or equivalently of frequency, relates closely with hearing which is basically frequency sense. Thus the unification of hearing and force senses to generalized four-force sense suggests itself.

An objection against this identification is that energy increments are involved with all quantum transitions so that also vision would involve some kind of auditory aspect. Most audible frequencies are however above EEG range makes hearing especially makes possible to store a lot of information to auditory sensation whereas for other senses the content of dynamical information is so small that the auditory information of these senses remains un-noticed. Alternatively, the net energy flow in the direction of subjective time in turn could correspond to the intensity of the quale for all qualia. This would be in nice accordance with the universality of the kinesthetic qualia. The intensity of quale could however have other identifications: for instance, very entropic mental images should give rise to dim qualia.

One can wonder what the interpretation of Lorentz boosts, do they correspond to independent qualia or not? Very probably not: what is needed to characterize the basic qualia is quantum number increments for a maximum number of mutually commuting observables. Boosts induce increments of four-momentum and thus force and energy qualia.

Linear and angular acceleration

Magnetic states have well defined momentum and angular momentum component in the direction of the magnetic field and the sensation of acceleration or force in the direction of the magnetic field

and angular acceleration around this direction naturally correspond to a quantum phase transition changing the momentum and angular momentum of charged particles of the macroscopic quantum phase. For instance, sensations of falling in gravitational field and sensation of dizziness when the world rotates around could be related correspond to primitive angular acceleration quale.

Note that it is also possible to have state basis for which two momentum components are well defined quantum numbers with suitable choice of gauge. In TGD framework the choice of gauge is not however completely free since classical fields are induced from CP_2 spinor connection. For instance, canonical transformations of CP_2 acting formally as $U(1)$ gauge symmetries of the Kähler potential do not act as ordinary gauge symmetries but isometries of WCW and deform space-time surface and affect classical gravitational fields.

Identification as linear and angular acceleration probably makes sense when the experience is about body. If spin flip and increment of momentum are associated with an object of perceptive field they might give rise to figure-background separation in magnetic case. Object of perceptive field effectively “pops up” from the background or makes small twists with respect to the background. In this case the net changes of these quantum numbers vanish in the long run and kind of “twinkling” results. A classical example about the flipping of the figure-background identification between two alternatives is the figure in which Freud’s head and naked woman is seen alternately but never simultaneously.

Increment of orbital angular momentum and color flip are in general associated with the same Hamiltonian which can be chosen to be a product of functions in E^2 resp. CP_2 . Hamiltonians associated with E^2 can be chosen to be eigen states of the angular momentum in the direction determined by the point of flag-manifold. Functions are most naturally localized around point of E^2 and thus only angular momentum component J_z is good quantum number. The transitions are thus characterized by the increment $\Delta M = J_z$ of angular momentum and by the increments of color quantum numbers and for given color representation D infinite series of qualia or variants of same quale labelled by ΔM are possible. The identification of spin increment as related to polarization sense is very natural if color corresponds to the visual color. Polarization would be experienced as some kind of a torque of universality holds true.

Hearing as time-like counterpart of force sense?

As already found, a natural identification for the energy increment is as being related to hearing which would be thus time component of sense of four-force. This identification is elegant but perhaps formal and one must compare it with alternative possibilities.

The quantum model of hearing [K95] has evolved through painful steps. At this moment it however seems that basic auditory quale could correspond to an increment of electroweak spin at the level of cell membrane (see the discussion towards the end of the chapter). The increment of electroweak spin can be assigned to either quark pair assignable to a lipid of receptor membrane or a pair of quark pairs assignable to separate receptor membranes and joined by flux tube during sensory reception. The experienced pitch in turn seems to correspond to a quale of magnetic body and correspond to a frequency modulation of Josephson frequency by the frequency of the sound [K44] .

The modulation of Josephson frequencies would provide a completely general representation of sensory and other information at the magnetic body. Music metaphor allows to see this representation as analogous to that produced by a choir of whales. Both neurons and astrocytes are expected to sing and the value of Planck constant for a given neuron or astrocyte characterizes the octave associated with this particular singer. Speech and song would be direct motor expressions of this representation. Also ordinary speech involves frequency modulation as becomes clear by playing a recorded speech with abnormally slow rate.

Increments of spin and momentum and figure-background separation

In M_+^4 degrees of freedom there are two quantum numbers corresponding to the $SO(2) \times R$ Cartan algebra of $SO(3, 1)$. These quantum numbers can be chosen to be spin and momentum in direction of the quantization axis. It is probably of significance that just these quantum numbers are also associated with the magnetic states besides magnetic quantum number which is analogous to the conformal weight in the case of Virasoro algebra. This suggests that discrete magnetic qualia and

Super Virasoro qualia in Lorentz degrees of freedom might have a close relationship. Universality of the kinesthetic qualia indeed implies this kind of a relationship.

There is no change in orbital degrees of freedom involved with spin flip, which suggests that sensation of torque is not involved. A possible identification is in terms of figure background separation. In the case of magnetic qualia spin flips associated with the representations of objects of the external world could correspond to figure-background separation since transition frequencies for spin flip transitions are shifted with respect to the frequencies of transitions without spin flip. Indeed, by music metaphor the addition of the spin-flip frequency to the cyclotron frequency implies that figure is separated from background like dissonance from harmony.

There is also a second metaphor for what figure-background separation means. In order to separate figure from background one can to give it a small push upwards or perform a tiny twist for the figure with respect to background. This is what increments of spin and momentum in the direction of quantization axes could represent. This kind of tiny pushes and rotations would give vanishing net effect in the sequence of quantum jumps but take care that the object of the perceptive field gains attention. Perhaps this has something to do with the fact that primitive organisms like insects are unable to see objects which are not moving with respect to the surrounding world. Saccadic motion might be essential in generating artificially the motions separating figure from background: if saccadic motion is made impossible, visual field gradually falls in total darkness [J106].

“Push-or-twist” metaphor would allow to assign figure-background separation also to super-symplectic spin flips. For super-symplectic algebra transition frequencies of the transitions induced by classical gauge fields associated with MEs are however harmonics of the fundamental frequency and the generation of figure-background separation by the shift of the EEG frequency is not possible. This implies that there is infinite number of qualia or variants of the same quale associated with given increments of color quantum numbers.

4.3.5 Tactile Qualia

Concerning the identification of the tactile qualia (sense of touch, pressure sense, temperature sense, physical pain and pleasure), the first hint comes from the observation that a topological phase transition involving the formation of flux tubes with the object is involved. Thus the number of the join along boundaries contacts could play the number of particles in this case.

In the case of purely physical pain/pleasure (different from the emotional aspect of pain and pleasure) the splitting/formation of the flux tubes associated with the tissue occurs and the number of these contacts could define the relevant particle number. The purely emotional aspect of pain and pleasure in turn would correspond to the presence of entropy gradient with respect to the subjective time implied by this process. The most naïve interpretation is that primary sensory experience is located with skin since the replication of this kind of activity at brain level would seem somewhat artificial.

flux tubes are natural space-time correlates for quantum entanglement and their splitting means a loss of entanglement. Rational (algebraic) entanglement corresponds to positive information and also information is lost in the splitting process. At higher levels of dark matter hierarchy physical pain is replaced with more abstract psychic pain but the space-time correlate for it would remain same.

This is however not the only possible option. Also tactile qualia could be induced by EEG frequencies as our qualia at the level of cortex. This would mean a rather concrete representation of the topological aspects of tactile qualia. The fact that various objects of perceptive field are represented as recognizable patterns of neural activity supports the view that also tactile experiences are regenerated at the level of the virtual world of cortex. EEG waves should induce the generation and splitting of internal and internal-external flux tubes inside cortex and this requires that the energy for the generation of flux tube is extremely small, of order of 10^{-14} eV for 10 Hz frequency for ordinary value of \hbar : for $k_d = 40$ level of dark matter hierarchy energy is above thermal threshold. Note that the hypothesis is $h_{eff} = nh$, where n is product of distinct Fermat primes and power 2^{k_d} .

The flux tubes in question must be electric (magnetic flux conservation does not allow splitting of the bond). By assuming that the electric flux through the bond is given by elementary charge, one obtains that the electric energy associated with the bond is given by the potential

energy difference over the bond for electron. Josephson junctions with potential differences of this order of magnitude should be indeed present in bio-matter and the number of the Josephson junctions would become the basic variable. The Josephson junctions acting as join along boundaries bonds/flux tubes could be also MEs, which indeed can have very small thickness and can carry also constant component of electric and magnetic fields in the case that they appear as pairs (the throats of wormhole contacts connecting the members of ME pair would serve as sources of these fields).

The purely physical aspect of the temperature sense (as opposed to the emotional aspect) most naturally corresponds to energy flow in the direction of subjective time. Temperature sense would be energy sense basically. Sensors for cold and hot would detect consciously the flow of energy from body/into body and code this into increment of energy for magnetic or super-symplectic states. The average increment of transition frequency using p-adic frequency scale as unit would measure the intensity of sensation.

4.3.6 Emotions

The thermodynamical approach by replacing second law with NMP suggests that emotions correspond to the gradients with respect to subjective time for various entropy like variables associated with sub-systems of self. Thus positive/negative emotions should reflect the increase/decrease of order. This identification is supported by the general characteristics of emotions.

Emotions contain only few bits of information but this information is very important for survival. Emotions are holistic, “single-pixel” qualia and about the state of the entire body or relatively large part of body. Emotions are very much like conscious representations for time rates for the deviations from homeostasis realized as many-sheeted ionic flow equilibrium and tend to appear in complementary pairs. Emotions correlate very strongly with the chemical state of the body. In particular, peptides are often regarded as both the molecules of emotion as well as of information. Since peptides perform bio-control as information molecules they must induce especially intense entropy gradients with respect to subjective time and thus strong emotions if TGD view is correct.

In the sequel TGD view about emotions are compared with the ideas of Damasio described in his book [J20]. To avoid confusions it is good to emphasize that in TGD approach emotions are defined as sensations rather than as motor responses to sensory input about state of body as Damasio defines them [J20]. In the following various classifications of emotions and various aspects of the concept of emotion are discussed. After that the general identification of emotions as generalized sensory qualia about state of body and CNS containing both geometric and non-geometric component is described.

About classification of emotions

In order to even try to say something sensible about the identification of correlates of emotions, one must try first to try to develop general view about different kinds of emotions.

1. One classification of emotions [J39] is based on the notions of cognitive world model and goal structure. The simplest emotion is excitement which does not involve any recognizable goal or cognitive model. Surprise and relief involve conflict or resolved conflict between prediction of model world and real world experience. “Amygdalar emotions” fear, anger, craving, protection and disgust are directed and involve goals and external threats to goals. Also cortico-striatal emotions like sadness, hate, embarrassment, contentment and joy involve goal structures and failure or success to achieve the goal in essential manner. A general representation for goal should be in terms of generalized geometric qualia representing the desired state of body or some other system and represented as mind like space-time sheets.
2. Damasio classifies emotions to six universal “big” emotions: happiness, sadness, fear, anger, surprise and disgust; to background emotions or moods (feeling good/bad, tired, excited, depressed, strong, ..) and to social emotions (feeling embarrassed, ashamed, guilty, ..). One can also classify emotions to bipolar pairs (fear/anger, craving/disgust, pain/pleasure, ...) according to whether they involve approach or withdrawal from some situation (fight or flight) or ambivalent rest and digest emotions (surprise, excitement) or emotions related to

seeking of pleasure. Drives induce emotions like hunger or thirst and satiation follows the achievement of the related goal. The dichotomic nature of these emotions conforms nicely with the fact that Super algebra generators appear as complementary pairs.

3. If simple emotions are just generalized sensory qualia, it is natural to interpret emotional expression as a generalized motor action so that motor action, imagination and emotional expression would be very much analogous to each other. It is known that the expression of emotions is indeed very brain area specific and hence very much analogous to motor expression [J20]. The ideas about e-motor expression and emotional imagination sounds perhaps strange since emotions are often regarded as something which just come from heaven and do not involve volition. This is not the case always: for instance, actors have specialized in practicing e-motor activities. Damasio tells in his book about pianist who told about emotional currents going through her body and about her ability to control them at her will: it turned out that this ability had direct neurophysiological signatures. One can also distinguish between active and passive emotions. For instance, pleasure and craving, anger and hate, and fear and anxiety (not a direct reaction) differ in that they are passive/active emotions.
4. Some metaphorical representations of emotions as qualia like tastes and basic tactile senses [(warm, cold, pain) at least] appear very naturally. This could be understood if also emotions are accompanied by super-symplectic qualia. As already found, there are however strong objections against this identification.
5. The fact that emotions are holistic “single-pixel” experiences suggests that emotions represent experiences about average state of body or body part. This averaging is natural if emotions correspond to $k = 67_3, 101_2$ and/or $k = 103_2$ level sensory qualia at length scales 32, 45 and 180 cm and are determined as reactions to what happens in shorter length scales. Of course, also shorter length scales $L(k)$, $k = 191, 193, 97_2, 197, 199$ could be involved.
6. There are also very refined emotions like those accompanying music experience. It is not at all clear whether these emotions can be regarded as representing “average pixels” of lower level sensory experience about body and might be primary emotions experience directly and correlating with the patterns of ELF em waves. One can indeed assign to the Fourier decomposition of EEG wave entropy in terms of the probabilities defined by the Fourier coefficients of EEG wave and the gradient of this kind of entropy with respect to subjective could correlate with the emotional aspects of music. White noise and monochromatic sound (and more generally EEG wave) would represent the two extremes. Interestingly, $1/f$ noise for the distribution of frequencies and durations of notes is a characteristic of musical sounds. The assignment of entropy gradients with respect to subjective time (this is important!) as correlates of aesthetic experiences is indeed natural.
7. There are also emotions which indeed seem to “come from heaven”. It is difficult to believe that religious and spiritual experiences could be mere representations of the state of body and CNS. More feasible assumption is that these emotions are communications from the higher levels of self hierarchy to our level. Communication mechanism would be semitrance mechanism transforming the communications to emotions and e-motor actions. Probably a loop in which selves below us in self hierarchy are affected and yield e-motor expression which is perceived by us and in turn stimulates emotion at our level.

How emotions differ from ordinary sensory experiences?

Emotions differ from ordinary senses in that they seem to be relatively simple in some respects. Instead of providing a detailed picture with each pixel having several possible colors they seem to provide a single big pixel. Thus a plausible view about emotions is as “single pixel qualia” associated with the levels $k = 67_3, 101_2$ and $k = 103_2$ levels of the self hierarchy (at least). There are also alternative explanations for the diffuse character of emotions. These explanations are however consistent with this first principle explanation.

1. The sensory information about internal milieu is about pH, ionic concentrations, hormone levels, .. and thus not topographical bit map type information. If this information dominates emotional input, it is easy to understand why emotions tend to have single pixel character: the color of the pixel simply varies very slowly. Also the control of moods by mono-aminergic and catecholaminergic and other neuromodulator systems is based on diffuse projections. On the other hand, the somatosensory information from muscles (in insular cortex and some regions of parietal lobe), known to be important for emotions, has bitmap character. One could also see the correlation of emotions with peptides and other important bio-molecules whose presence induces large entropy gradients as a direct support for the view that emotions are associated with entropy gradients.
2. Our emotions are determined to a high degree by experiences which are averages....over averages over all sub-selves of the lower level self. These averages replace a picture containing very many colored pixels with single pixel picture having the average color. The generalized sensory experiences of the lower level selves are in turn determined by the input from muscles, smooth muscles and inner environment and by hormonal communications.
3. It could be also that at least some emotions (for instance, those involving comparison of what happened with long term goals) are communicated to us from the higher levels of self hierarchy. The primary communication could be to some lower level self and we would experience these emotions both as averaged experiences and by reading our body language (also the body language spoken by the inner organs) language. Unconscious-to-us sensory qualia also induce e-motor reactions realized as bodily expression of emotion. We perceive this bodily expression and it affects strongly our emotional state. Thus there is close relationship between pure emotional coloring and the generalized geometric qualia inducing it. This option is consistent with the ideas of Damasio about self hierarchy [J20].

According to Damasio [J20], the ability to experience and express mood like emotions is preserved even when neocortex suffers lesions destroying practically all cognitive abilities and the ability to process sensory information and respond to it. On basis of this fact Damasio suggests that mood like emotions are associated with “pre-self”. Pre-self is prerequisite of nuclear consciousness and extended consciousness involving cognition and long term goals [J20]. The regions assigned by Damasio to “pre-self” correspond to the nuclei of brainstem, hypothalamus, basal forebrain, insular cortex and somatosensory regions (S1 and S2) in the medial parietal cortex. Perhaps these regions represent sub-selves which receive the sensory input determining our emotions. The hypothesis that primary and secondary regions of the cortex correspond to the first and second period of the periodic table and do not correspond to sensory input directly conscious-to-us is consistent with this picture.

Can one identify emotion with its expression?

There are empirical data supporting Damasio’s view that our emotions can be identified with their expressions. For instance, if the motor pathways in the reticular formation are destroyed, person is unable to perform volitional movement and the bodily expression of emotions becomes impossible. Contrary to what one might expect, the patients are calm and peaceful although they can feel frustration and sorrow at intellectual level. Damasio interprets this as support for the correctness of the identification of emotions with their bodily expressions.

The sharp distinction between emotional and purely sensory aspects of pain can be understood if emotions accompany generalized sensory experiences. The purely sensory aspect of pain would correspond to non-geometric and geometric qualia giving information about the state of body and CNS whereas emotional coloring would be due to the entropic gradients necessarily involved with the sequence of the quantum jumps. The reason why sensory input from our body induces much stronger entropic gradients than that from the everyday external world would be dictated by the relatively higher importance of this input and positive feedback loops exaggerating the entropic gradients from body might quite well be involved. That also the sensory input from external world can induce emotional reactions is in accordance with this view.

A more detailed TGD based model of emotions consistent with the observations of Damasio is following. Emotions are based on sensory perceptions about the state of body directly by some

lower level self, perhaps the “pre-self” of Damasio. We experience these qualia as averaged qualia which is much like objective sensory perception: emotions provide summaries rather than bitmaps. The more levels there are between the primary experiencer the slower is the dynamics of emotions and moods correspond therefore to the lowest level self, perhaps the level of “pre-self” of Damasio. The lower level self reacts to its emotional percepts by e-motor activity generating emotional expression affecting the state of body and of internal organs, which higher level selves in hierarchy and also we in turn perceive. The entropic gradients characterizing this perception determined the emotion and in turn the reaction and it is easy to imagine a positive feedback generating a response which contains increasingly stronger entropic gradients. It seems to be the perception of the e-motor responses of pre-self to which cause mostly the suffering at our level.

If lower level self of the patient is not able to react e-motorially to its emotional percepts, the patient do not get in a state of horror. Of course, an open question is what “pre-self” experiences, when it cannot express its experiences: not necessarily anything dramatic and not necessarily anything emotional. It might be that the holistic nature of emotional content is essentially due to single pixel character of emotional experience. Note that this feedback loop resembles the loop created by typing text or talking loudly one’s own thoughts. Lower level self communicates directly to us via our body using body language and via lower level selves below us via nervous system. This model explains also why many bodily expressions of emotions occur before we become conscious about them.

Peptides as molecules of emotion and information molecules

It is known that peptides correlate strongly with emotions and moods [J29] and they are even called molecules of emotions. Peptides are also regarded as information molecules. This connection between information and emotions fits nicely with the fact that peptides and other important biomolecules certainly induce strong entropy gradients with respect to subjective time. We do not taste or smell the presence of peptides or other information molecules in our body. A possible explanation is that Bose-Einstein condensation of peptides on super-conducting space-time sheets does not occur. This could quite well be the case for the simple reason that peptides are macromolecules. Of course, one could also argue that the color of emotion is nothing but a generalized taste or odor.

Although it looks more plausible that peptides are only one step in a control sequence leading to quantum phase transition giving rise to quale, one cannot rule out the possibility is that also magnetic transition frequencies of peptides (short proteins acting as hormones) correspond to geometric aspects of emotional qualia. The cyclotron frequencies of singly charged amino-acids are in the range of 1 – 4 Hz and it is known that proteins carry constant charge density per unit length. If this density is same as for DNA, the charge per protein would be about 6 elementary charges. For unit charge per single protein $n = 1$ cyclotron transition is in delta band whereas for 6 elementary charge per unit $n = 1$ cyclotron transition frequency is in alpha band and would be conscious-to-us.

Since proteins and DNA are spin glass type system allowing huge number of ground states and angular momenta, explosion in complexity is expected to occur and make possible extremely rich spectrum of geometric aspects of emotions.

What emotions could be in TGD framework?

TGD suggests several visions about emotions and it is not yet completely clear whether these views are really mutually consistent.

1. The statistical physics approach to qualia leads to the hypothesis that emotions correspond to rates for the generation of various type of entropies for sub-systems of self. The sign of rate tells whether emotion is positive or negative and thus negative emotions would thus be conscious control variables warning self when some sub-system is generating entropy. The holistic nature of emotions can be understood easily in this picture and also the fact that they are not directly related to sensory input. One could perhaps also understand higher level emotions like sorrow as reflecting the growing disorder of the virtual world of brain resulting from the primary cause of sorrow. The connection of peptides and other information molecules with emotions provides a strong support for this view.

2. Many emotions are comparison type emotions. These emotions tend to be negative (say envy).
 - i) At fundamental level one could perhaps regard comparison type emotions as resulting from the comparison of geometric and subjective memories occurring automatically in any quantum jump and thus to some degree with any quale. Unfortunately, it is very difficult to imagine how to concretely test this kind of hypothesis and it is also difficult to see how the connection with entropy gradient could emerge.
 - ii) One must also seriously consider the possibility that emotions result from the comparison of remembered/anticipated quale and real quale rather than the fundamental comparison involved with anticipation and memory: kind of quasi-computerized version of geometric memory would be in question. The result of comparison would be coded to the sign of the growth rate of some entropy variable. The comparison could perhaps be realized in such a way that subsequent quantum jumps for comparing sub-system could represent either the anticipated or real quale. If this were the case, the difference between anticipated and real would automatically induce growth of entropy and negative emotion would result. This would be the basic mechanism of disappointment.
3. One could also regard emotion as or induced by generalized sensory qualia giving information about CNS itself rather than external world or the boundary between external world and body. Regulation involved with the homeostasis involves comparison in an essential manner so that one could perhaps regard emotions as analogous to control variables representing consciously the result of comparison of expected and desired forcing the organism to behave in a way to reduce this difference and end up to a rest and digest state. This aspect is consistent with the statistical interpretation since the entropy gradients associated with the organism are stronger than those associated with surrounding world. Also amplification mechanisms exaggerating the entropy gradients might have developed. For instance, our reactions to some odors or tastes could involve this kind of amplification.
4. A hypothesis consistent with these views is that emotional component is involved with all sensory experiences and that we are used to call generalized sensory experiences emotions when they are about body. The emotionality of qualia indeed increases in the sequence of perceptive fields external world – CNS-world boundary – body. The degree of emotionality of experience should be characterized by the deviation of real from expected or desired and this suggests that the emotional component is much stronger for sensory experiences about CNS itself, since the system in question is much less predictable than the external world consisting of dead objects. Interpretation of emotion as measure for entropy gradient explains also this hierarchy.
5. A further point of view is provided by music metaphor. Music is language of emotions which suggests that emotions are at least partially coded into the EEG pattern. Perhaps pure emotions which seem to involve no obvious comparison (love, joy, excitement, ..). At least the emotions produced by music might represent this kind of emotions. The view about emotions as entropy gradients allows to understand also emotions of this kind. In state of deep love, self enters into very low-entropy state and mental images (not necessarily even present in “enlightened states”) become very pure. Comparison type emotions could be seen as a system of rewards and punishments used to control the self (the controller could be higher level self (conscience) or higher levels selves which also want to survive (the emotions generated by hunger, first, and physical pain)).
6. Sensory qualia can be divided to geometric and non-geometric ones. One can classify also emotions in this manner. Emotions corresponding to the localization in zero modes would perhaps correspond to “higher level emotions” about external world (say, aesthetic qualia) whereas the non-geometric emotions associated with the state preparation would correspond to “self-centered” emotions about the state of body (pain, physical pleasure, ...).

Some examples of concrete identification of emotions

In the following some examples about the identification of emotions are discussed to see what problems are encountered in attempts to concretize the general theory.

1. Simple emotions

Pleasure and pain are the most important emotions (pain as emotion must be distinguished from physiological pain which is ordinary sensory experience). The identification as conscious entropy type variables works very nicely in this case. Relief and disappointment are examples of simple emotions induced by some unexpected event and involving comparison and goal structures. Emotions as entropy gradients vision allows to understand these emotions along the lines already described. Surprise is an ambivalent emotion which is associated with the deviation between expected and real. The lack of comparison aspect could be understood if surprise involves a generation of totally new mental image. Getting bored is more or less a complementary emotion to surprise. It probably involves the growth of the entropy content of the mental images. There are six basic emotions involving goal structures arrangeable into two triplets (happiness, sadness, craving) and (fear, hatred, disgust) or three doublets (happiness, sadness), (fear, rage), (craving, disgust). These emotions are comparison type emotions allowing description in terms of entropy gradients.

2. About geometric aspect of emotions

Simplest comparison type emotions involve comparison of the model of reality with reality. More complicated emotions involve goals and their comparison with what was achieved. This suggests that world model and abstract goals can be mapped to the generalized geometric qualia. The metaphorical correspondence of emotions and motions suggests that flag-manifold qualia indeed could represent abstract goals and cognitive structures. The infinite-dimensional flag-manifold associated with the group of zero mode canonical symmetries of WCW must describe the geometric aspect of emotional experience. This gives huge flexibility and good hopes of coding various goals to the geometry of the space-time sheet (and thus also to cyclotron frequency) by applying appropriate canonical transformation to it.

The most concrete goals are expressible as desired position and posture of body. Consciousness builds geometric metaphors for abstract concepts and goals and metaphorizes also abstract evolution in terms of simple dynamical concept. For instance, goals are often metaphorized using expressions like achieving certain position in society. This suggests that various metaphorization might have developed from these concrete “geometro-dynamical” goals. Therefore one must take seriously the possibility that flag-manifold qualia associated with Lorentz and color group can code also geometric aspects of emotional experience. This reduction could be also due to the fact that flag-manifold coordinates must be eventually mapped to concrete standard configurations of the magnetic flux tubes characterized by position, orientation and internal states achieved by applying Lorentz boosts in the longitudinal direction of tube.

3. Higher level emotions

TGD suggests that higher level emotions are communicated to us by higher level selves by semitranscence mechanism in which some part of brain, presumably belonging to right temporal lobe and including hippocampus and amygdala, entangles with higher level self and serve as a medium allowing higher level self to communicate its message as emotions, sensory “hallucinations” or internal speech as nerve pulse patterns to the audience consisting of those parts of brain which are in wake-up state. The physical correlate for this process would be standing EEG waves which in turn correspond to spatially constant “space-like” soliton sequences associated with the region of brain serving as medium whereas propagating EEG waves are associated with soliton sequences propagating in linear circuits of brain. The standing wave part of EEG would clearly correspond to “free part” of EEG wave not induced by sensory experience alone and identifiable as active aspect of collective consciousness represented by ELF MEs.

The assumption of Damasio that emotion accompanies a generalized sensory experience about the state of body seems to be in conflict with the idea that higher level emotions are communicated to us by higher level selves. Entropic interpretation of emotions does not require that emotions are always about state of body. One the hand, body could serve as an instrument making possible to represent higher level emotions. Higher level self could use semitranscence mechanism to induce nerve pulse patterns giving rise to characteristic temporal patterns of EEG in turn giving rise to communicated emotions. Higher level selves could also induce neural activity at some lower level of self hierarchy which would in turn be experienced by us as average emotions like moods.

For instance, higher level selves above us could be responsible for the higher level social emotions like shame and experience of having done something wrong. The experiences of higher level self could be communicated to us, or rather to our lower level sub-selves, as kind of artificially generated virtual world emotions which correspond to EEG frequencies which are higher octaves of the magnetic transition frequencies associated with the fundamental experience. p-Adic length scale hypothesis implies that this communication optimal. The spectrum of super-symplectic frequency scales indeed comes as powers of 2 for primary p-adic length scales: if secondary and higher p-adic length scales are included, frequency scales come as powers of $\sqrt{2}$.

4.3.7 Dark Matter Hierarchy And Emotions

The ideas related to dark matter hierarchy led to a progress in the attempts to understand what emotions and cognition might correspond physically. The new views discussed in more detail in [K98] challenge the assumption that emotions reduce to negentropy gradients and suggest that the sensory qualia of the magnetic body assignable to cyclotron phase transitions correspond to emotions and cognitions. Only the negative-positive coloring of emotions would reduce to the sign of the negentropy gradient in this framework. In the following earlier view and the dark matter inspired vision about emotions are confronted.

Emotions as higher level qualia?

Emotions have metaphorical resemblance to qualia (white/black, cold-warm, ...) but intuitively correspond somehow to a higher level than sensory qualia. For instance, insects presumably possess sensory qualia but do not look emotional. Pain-pleasure dichotomy is especially interesting since physical pain can be regarded as a sensory quale and psychological pain as an emotion. This suggests that emotions might be qualia of some kind, perhaps sensory qualia of the magnetic bodies at higher levels of the dark matter hierarchy. This correspondence might however be illusory: the association of certain kind of emotions with certain kind of qualia could explain these metaphors.

It is not at all clear whether this identification is consistent with the assignment of emotions to the negentropy change. One can of course ask whether the “sign” of the emotion as a higher level sensory quale is determined by the sign of the negentropy change. One could also argue that the sign of the negentropy change for sub-self defines one particular higher level sensory quale.

Emotions are whole body feelings

Emotions are holistic and not localizable in any part of the biological body. The time scale for the change of emotions is long as compared to that for the sensory qualia. Emotions possess time scale hierarchy and vary from temporary irritation as you find that you email box is full of junk mail to moods and emotional states like love and hatred lasting for decades. To love some-one for decades one must be able to remember this person. If one assumes that the time scale associated with the level of dark matter hierarchy fixes the geometric duration of the moment of conscious and the characteristic time span of long term memories at that particular level of hierarchy, the conclusion would be that emotions are associated with the higher levels of dark matter hierarchy and are indeed assignable to the magnetic bodies.

Could Josephson radiation to the magnetic body generate emotions?

The simplest hypothesis is that magnetic bodies share the sensory mental images localizable at the sensory organs. The same would hold true for the mental images generated by brain as symbolic representations of the sensory input. The sharing of mental images would correspond to quantum entanglement between sub-selves of the magnetic body and biological body. Charge entanglement induced by W MEs is a good candidate in this respect and would be also in a key role in the motor control. The selection involved in the state function reduction process would correspond to a selection of percepts known to occur (binocular rivalry provides a standard example).

This leaves open the interpretation of the communications to the magnetic body based on Josephson radiation at frequencies $n f_c \pm f_J$, where f_c is ionic cyclotron frequency and f_J Josephson frequency determined by membrane resting voltage. Also more general frequencies are possible.

In particular, communications based on slow (in cyclotron time scale) modulations of Josephson frequency induced by modulation of membrane voltage are of special interest.

The Josephson radiation consisting of dark photons induces cyclotron transitions at the magnetic body and in the absence of any other identification, the natural interpretation would be that these transitions define emotions as somatosensory experiences of the magnetic body. The intentionally generated generalized motor actions involving charge entanglement by W MEs would induce the emotional expression just like other motor interactions.

If magnetic body experiences emotions as somatosensory input, it is difficult to avoid the question whether magnetic body is also able to move and change its shape. The model for various kind of OBE experiences [K124] indeed relies on the assumption motor control is induced by motor actions deforming the magnetic body: biological body would be like a puppet hanging from strings.

There is quite recent finding that the sensation of movement is generated by the intention to move rather than by the real motion of body part itself [J16]. The explanation would be that the sensation of movement is a somatosensory of magnetic body about its own motion (the interference patterns for Josephson radiation from the body are changed and therefore also cyclotron transition patterns). The communication-control loop between magnetic body and biological body would guarantee that the two movements correspond to each other. This interpretation would provide also a new view about dreams and hallucinations.

4.3.8 Dark Matter Hierarchy, Hierarchical Structure Of Nervous System, And Hierarchy Of Emotions

One can ask how the structural and functional hierarchy of CNS and the hierarchy of emotions relates to the dark matter hierarchy. The basic picture wherefrom one can start is following.

1. The emergence of nervous system corresponds to the emergence of $k_{eff} < 205$ levels of dark matter hierarchy above $k_{eff} < 167$. For instance, worms and insects would correspond to this level.
2. Vertebrates have EEG and thus the most primitive vertebrates (reptiles) should correspond to $k_{eff} \geq 205$.
3. The emergence of new structures need not mean the emergence of new levels of dark matter hierarchy. Rather, the most reasonable criterion for the presence of these levels is the emergence of behaviors involving long term goals and the magnetic bodies of the parts of brain assignable to the control of this kind of behaviors would correspond to higher values of k_{eff} . Also the maximum span of memories at given level should be characterized by the value of k_{eff} associated with the brain structures involved (hippocampus, mammillary bodies). This picture conforms with the fact that already insects possess neurons, ganglia, and head containing the predecessor of cerebrum but correspond to $k_{eff} \leq 205$ most naturally.

For goal related emotions the maximal time scale assignable to the achievement of the goal might allow to identify the time scale characterizing corresponding level of dark matter hierarchy. The lowest level emotions would be “primitive” emotions not related to any goal and one can as whether they could be assigned to organs consisting of ordinary cells and correspond to $k_{eff} \leq 205$.

1. The time scale of planned behavior and of long term memories makes possible to estimate upper bounds for the values of k_{eff} assuming Josephson frequency hypothesis. $k_{eff} \leq 205$ would give the upper bound of 6 ms which corresponds to cerebellar resonance frequency 160 Hz. This time scale looks too short even for the simplest vertebrates and one must be very cautious here.
2. An alternative interpretation is as the shortest possible span for short term memory whose time scale is known to vary.
3. Cerebellar rhythm could be analogous to hippocampal theta rhythm and involved with the cerebellar memory storage and therefore would not tell anything about the span of the memory but would characterize the time resolution of memories and planned actions. The role of cerebellum in the fine coordination of motor actions indeed requires high time resolution.

Brain has anatomic division into midbrain, hindbrain, and forebrain [J4]. Midbrain and hindbrain (sometimes both are included in brain stem) is possessed by even the most primitive vertebrates and its emergence could therefore correspond to the emergence of $k_{eff} \geq 205$ levels and EEG. The emergence of these levels relates naturally to the emergence of long term planning of motor actions in motor areas. The emergence of limbic brain, which defines the most primitive forebrain, could mean the emergence of the Gaussian Mersenne defined by $k_{eff} = 239$ containing dark electron condensates level and goal related emotions. This conforms with the fact that for mammals forebrain and cerebral hemispheres dominate whereas for other vertebrates hindbrain and cerebellum are in the dominant role.

Reptilian brain as $k_{eff} \leq 205$ system?

Reptilian brain contains only the structures corresponding to brain stem (midbrain and hind brain, in particular cerebellum) and as far structures are considered would correspond to $k_{eff} \leq 205$ levels of the hierarchy. Cerebellum is not believed to contribute directly to our consciousness. The absence of higher looks however an unrealistic assumption since reptiles certainly have long term memories.

Simplest emotions correspond to emotions involving no goal. Moods like excitement, feeling good/bad/tired/strong, etc.. could represent examples of such emotions and could be experienced already by reptilians. Of course, the scaled up variants of these emotions could appear at higher levels of hierarchy and would relate to the states of magnetic bodies (degree of the quantum coherence of Bose-Einstein condensates!).

Limbic system

Limbic system is not possessed by reptiles [J10]. It is responsible for emotions, control of emotions, and also emotional intelligence. Limbic system corresponds to the brain of the most mammals. The limbic brain includes the amygdala, anterior thalamic nucleus, cingulate gyrus, fornix, hippocampus, hypothalamus, mammillary bodies, medial forebrain bundle, prefrontal lobes, septal nuclei, and other areas and pathways of the brain.

1. The sub-cortical part of the limbic system involves amygdalar and septal divisions. According to [J10] amygdalar division promotes feeding, food-search, angry, and defensive behaviors related to obtaining food. Septal division promotes sexual pleasure, genital swelling, grooming, courtship, and maternal behavior. These divisions are emotional mirror images of each other hand could correspond to $205 < k_{eff} < 239$.
2. The cortical part of the limbic system contains cingulate gyrus which is the newest part of the limbic system and belongs to thalamo-cingulate division which promotes play, vocalization (e.g., the separation cry), and maternal behavior. The time scale of memories would be shorter than 3.4 at this level.
3. Frontal lobes [J6] are often regarded as the organ of volition. The frontal lobes are involved in motor function, problem solving, spontaneity, memory, language, initiation, judgement, impulse control, and social and sexual behavior. Prefrontal lobes representing the extreme front part of frontal lobes belong also to the limbic system and are responsible for motivation and ability to pose long term goals. This ability distinguishes humans from other primates. For these reasons frontal lobes, in particular prefrontal lobes, could involve the highest levels of dark matter hierarchy in the case of humans. The Gaussian Mersenne levels $k_{eff} = (239, 241)$ could be assigned as lowest level in this hierarchy. The time scale of long term memories would be longer than 3.4 years at these levels.

Cortico-striatal emotions like sadness, hate, fear anger, surprise, embarrassment, happiness, contentment, and joy involve goal structures and failure or success to achieve the goal in essential manner and would involve prefrontal lobes.

These levels would naturally relate to collective levels of consciousness coded by hyper genes. Hence these emotions could also relate to goals not directly related to the fate of biological body. Mirror neurons are a crucial prerequisite of a social behavior (autistic children seem to lack them), which suggests that hyper genes are involved at least with them.

Social emotions (feeling embarrassed, ashamed, guilty, loved, accepted, ...) could be induced by the collective levels of dark matter hierarchy as punishments or rewards for social behavior very much like neurotransmitters are believed to provide rewards and punishments at neuronal level.

Neocortex and two kinds of intelligences

Neocortex is often assumed to be superior (“neomammalian”) part of the brain and makes the majority of brain hemispheres. The species which are considered to be highly intelligent, such as humans and dolphins, tend to have large amounts of neocortex. The amount of neocortex is roughly proportional to the brain size for primates.

Neocortex cannot correspond to $k_{eff} \geq 239$ (defining Gaussian Mersenne) as a whole. The decomposition of sensory areas to layers is consistent with the presence of lower levels since it is time resolution which matters in the case of sensory representations. Same conclusion applies to sensory association areas. The fine tuning of the motor control performed by cerebellum is consistent with $k_{eff} \leq 205$. Intelligence understood in the conventional sense of the word is accurate, works fast, and is computer like. The part of neocortex responsible for ordinary intelligence would be a rapid and accurate processor of sensory and cognitive representations. Hence $k_{eff} < 239$ would naturally characterize sensory areas, secondary and primary motor areas, to hippocampal representation of declarative memories, and all association areas except dorsolateral prefrontal sensory-motor association cortex where short term memories are represented.

Emotional intelligence works slowly and is responsible for visions and holistic views and would thus correspond to higher levels of dark matter hierarchy. Limbic system is involved with emotions, motivation and long term planning and would thus be responsible for emotional intelligence. Indeed, the damage to frontal lobes [J6] need not affect ordinary intelligence but affects emotional intelligence.

The levels of dark matter hierarchy associated with short and long term memory

The first thing to ask is of course whether the notions of short and long term memory make sense in TGD framework. Indeed, it would seem that it is more natural to speak about hierarchy of memories with characteristic time scales coming as selected powers of two.

1. According to [J14], the span of other than visual short term memories is 30-45 seconds. This requires $k_{eff} \in \{217, 218\}$.
2. Visual short term memories [J1] representing selected features of visual field are reported to have time span of few seconds. This suggests $k_{eff} \in \{213, 214, 215\}$.
3. Iconic visual memories representing entire visual field have much shorter time span of order 1 s: $k_{eff} \in \{211, 212\}$ would be appropriate for them,
4. Long term memories would correspond to $k_{eff} > 218$.

Hippocampus and mammillary bodies involved with long term memory recall are part of the limbic system. The hippocampal theta rhythm 4-12 Hz, which could corresponds roughly to $k_{eff} \in \{163, 162, 161\}$ has nothing to do with the span of long term memories but would define the time resolution of the memories: the moment of sensory experience indeed corresponds to 10 Hz frequency. The frequencies responsible for memory storage need not have anything to do with the ultralow frequencies characterizing the temporal distance of the past event associated with the memory recall and hippocampus could just build a kind of bit sequence which during memory recall is communicated from the geometric past to some part of the future brain or magnetic body.

Anterograde amnesia means an inability to restore long term memories. The damage of hippocampus or of mammillary bodies can induce anterograde amnesia. In the usual conceptual framework the explanation would be the inability to store new long memories. In TGD framework this would be inability to construct those cognitive representations which are communicated to the geometric future in long term memory recall. Retrograde amnesia seems to involve almost always anterograde amnesia and means loss of memories for some time span before the injury. A possible explanation is that injury can propagate also to the geometric past of the brain quantum jump by quantum jump.

During ageing memories tend to be lost but the memories of childhood are the most stable ones. A possible interpretation is that faster rhythms of the generalized EEG tend to disappear: kind of scaled up variant for the process of falling into sleep accompanied by silencing of higher EEG bands could be in question.

What about transpersonal levels of consciousness?

$k_{eff} > 245$ levels of dark matter hierarchy correspond to time span longer than 109 years and cannot relate to the biological body alone. They could relate to higher collective levels of the dark matter hierarchy and evolution of social structures. The memories extending over personal life span claimed by meditators could have interpretation in terms of $k_{eff} > 245$ transpersonal levels of consciousness. Also the “god module” located to temporal lobes could correspond to this kind of levels of dark matter hierarchy. If it corresponds to Gaussian Mersenne with $k_{eff} = 283$ the time scale of memories becomes huge: about 10^{14} years so that the notion of “god module” is indeed appropriate.

Boolean qualia, fermions, and memetic code

The original proposal for the realization of Boolean mind was in terms of sequences cognitive neutrino pairs. These can be interpreted as wormhole contacts carrying neutrino and antineutrino at the light-like wormhole throats and would thus represent boson like entities. In the framework of the standard model the proposal looks of course completely non-sensical. TGD however predicts the existence of long range classical electro-weak fields, and one might imagine that inside neutrino-whose Compton length corresponds to length scale of cell- intermediate gauge bosons behave like massless fields. Although neutrinos could be important, the time scale of corresponding CD - about 10^4 years - suggests that cognitive neutrinos might be important in much longer time scale than the .1 second time scale assignable to the memetic code.

The recent view about TGD allows a much more general view. Zero energy ontology allows to interpret the fermionic parts of zero energy states as quantum superpositions of Boolean statements of form $a \rightarrow b$ with a and b represented in terms of positive and negative energy parts of the zero energy state. If one has negentropic entanglement this kind of state has interpretation as an abstraction - a “law of physics” - representing as a quantum superposition various instances of a more general law.

The simplest situation corresponds to a CD having only single positive energy fermion and negative energy fermion at its light-like boundaries. The fermion number or spin or isospin of the fermion could represent qubit. The hypothesis that memetic code corresponds to the next level of Combinatorial Hierarchy, when combined with p-adic length scale hypothesis, led to a prediction of order .1 seconds for the duration of the “wake-up” period of sub-self corresponding to the codeword of the memetic code. Since the CD assignable to electron has time scale .1 seconds and the CD assignable to u and d quarks has time scale 1/1.28 milliseconds there is a temptation to propose that the quark-like sub-CDs of electronic CD give to a realization of memetic code word as a sequence of 126 quark like sub-CDs. u and d quarks would be assigned to the magnetic flux tubes connecting DNA and the lipids of the cell membrane in the model of DNA as topological quantum computer. Clearly, beautiful connection between new elementary particle physics, genetic code, nerve pulse activity, DNA as topological quantum computer, logical thought, and the basic time scales of speech are suggestive.

This codeword consists of 126 bits represented by quarks such that the two possible magnetization directions correspond to the two values of Boolean statement. This implies that the duration of single bit should 1/1260 seconds. The duration of the nerve pulse is slightly longer than this which might mean that the full memetic code is realized as membrane oscillations rather than nerve pulse patterns. Both hearing and vision have .1 second time scale as a fundamental time scale and sounds are indeed coded to membrane oscillations in ear.

One can consider also the realization of genetic code with six bits of the codon represented by various scaled up versions of quark CD coming as size powers of 2. In this case the ordering of the bits would come from the size of sub-CD whereas in previous example temporal ordering would define the ordering. It is not however clear whether the powers of two can be realized physically.

One can understand the number 126 as related to the total number of separately experienced frequencies in the interval 20 – 20.000 Hz spanning 10 octaves. $10 \times 12 = 120$ is not far from 126: here 12 corresponds to 12 tones of basic music scale. Also speech has 10 Hz frequency as fundamental frequency. In visual primary cortex replicating triplets, 4-, 5- and 6-plets of spikes with highly regular intervals between spikes have been detected. The triplets are accompanied by ghost doublets. This would suggest a coding of some features of visual experience to reverberating mental images. The time scale for various patterns is 1 seconds. This could be seen as a support for the realization of some degenerate version of the memetic code as nerve pulse patterns.

The model for the memetic code encourages the following conclusions.

1. Membrane oscillation/nerve pulse patterns correspond to temporal sequences of magnetization directions for quarks representing yes/no Boolean statements.
2. The spin polarization of quarks is changed from the standard direction fixed by the spontaneous magnetization in the direction of axon by a ME moving parallel to axon, and inducing membrane oscillation or even a nerve pulse. Nerve pulses could correspond to a degenerate memetic code resulting by frequency coding for which the number of distinguishable code words is 64, and would thus naturally correspond to the reduction of the memetic code to the genetic code.

A very precise correspondence with the basic structures of the genetic code results. mRNA \rightarrow protein translation corresponds to the translation of temporal sequences of magnetization directions to conscious cognitive experiences. Under very natural constraints the mapping to cognitive experiences is not one-to-one and the predicted degeneracy (2^{126} sequences correspond to $(2^{126} - 1)/63$ cognitive experiences) can be understood.

One might think that the full memetic code is an evolutionary newcomer and involved only with the logical thought: this would explain the completely exceptional characteristics of human brain. The full memetic code could be realized for certain regions of brain only. These regions certainly include auditory pathways responsible for the comprehension of speech.

4.4 Constraints On The Fermionic Realization Of Genetic Code From The Model For Color Qualia

The original model for DNA as topological quantum computer assigns to DNA nucleotides quarks at ends of flux tubes or quark pairs at the ends of wormhole flux tubes. This is only the realization that came first to my mind in TGD Universe where dark variants of quarks can define QCD like physics even in cellular length scales. One can actually imagine several realizations of the genetic code and the first realization is far from being the simplest one. It is enough to have four different particles or many-particle quantum states to build at least formally a map from A, T, C, G to four states. It is obvious that the number of possible formal realizations is limited only by the imagination of the theoretician. Additional conditions are required to fix the model.

4.4.1 Fermionic Representation

Consider first the fermionic representations in the general case without specifying what fermions are.

1. The original proposal was that DNA nucleotides correspond to flux tubes with quark q and antiquark \bar{q} at the ends of the parallel flux sheets extremely near to each other. Second option relies on wormhole magnetic flux tubes in which case quark pair $q\bar{q}$ is at both ends. Quarks u, d and their antiquarks would code for A, T, C, G. The spin of quarks is not taken into account at all in this coding: why not restrict the consideration to single quark. The total quark charge at given end of flux tube pair vanishes and flux tube ends carry opposite quark charges.

The nice feature of this option is that one could understand the generation of color qualia in the model of sensory receptor in simple manner to be discussed below. Even if one accepts the arguments supporting the view that dark quarks in cell scale are natural outcome of

the hierarchy of Planck constants, one could argue that the presence of both quarks and antiquarks does not conform with matter antimatter asymmetry (not that one can however identify the analog of matter antimatter asymmetry at DNA level).

2. Spin states for fermion pairs assigned with two parallel magnetic flux tubes with the magnetic field generated by spin provide much simpler representation for nucleotides. Similar fermion pair would reside at the second end of flux tube pair.
 - (a) It is essential that rotational symmetry is broken and reduces to rotational symmetry around the direction of flux tubes so that spin singlet and spin 0 state of triplet mix to form states for which each fermion is in spin eigenstate. The states must be antisymmetric under exchange of the protons and spin 1/0 states are antisymmetric/symmetric in spatial degrees of freedom (wave functions located to the ends of flux tubes). The states with definite spin for given flux tube are mixtures of $s=1$ states with vanishing spin projection and $s=0$ state.
 - (b) It is not quite clear whether one should treat fermion pairs as identical bosons with 3+1 spin states since in TGD framework one considers disjoint partonic 2-surfaces and the situation is not that of QFT in M^4 . This interpretation would require total symmetry of the states under permutations of bosonic states defined by the 3+1 spin states. Coding by spin requires that each nucleotide corresponds to a state with a well defined spin. In field theory language the state would be obtained by applying bosonic oscillator operators generating states of given spin localized to a given nucleotide position.
 - (c) The classical correlate for the permutations of coordinates of fermions has interpretation as braiding for the flux tubes of the flux tube pair. In the similar manner the permutation of the flux tube pairs associated with nucleotides has interpretation as braiding of the 3-braids formed from flux tube pairs. Braiding therefore gives a representation of spin analogous to the well-known orientation entanglement relation invented by Dirac and providing geometric representation of spin 1/2 property.

4.4.2 Various Options For The Fermionic Representation Of A, T, C, G

Fermionic representations allows several options since fermion can be electron, u or d quark, or proton. Wormhole magnetic fields would not be needed in this case.

1. The problem of electron and proton options is that it does not allow realization of color qualia. There is also the well-known problem related to the stability of DNA caused by the phosphate charge of -2 units per nucleotide. Somehow this charge should be screened. In any case, the charge -2 should correspond to the electron pair at the DNA end of the flux tube for electron option. For proton option the charge would be screened completely. One could of course consider also the large \hbar color excitations of ordinary protons instead of quark at its nucleotide ends. This option would however require the modification of quark wave functions inside proton and this option will not be discussed here.
2. Quark option would give rise to both color and allow also to reduce the electronic charge of -2 units by 4/3 units to -2/3 units in the case of u quark pair. This would help to stabilize DNA. In the case of d quarks the charge would increase to -10/3 units and is not favored by stability argument. Flux tube pairs assigned to single nucleotide define diquarks with spin 1 or spin 0.
 - (a) Diquarks behave as identical bosons with 3+1 spin states and 3×3 color states. They form formally super-multiplet of $\mathcal{N} = 2$ SUSY. The states with well defined symmetry properties in spin degrees of freedom have such properties in spatial degrees of freedom. This means that one obtains a superposition of flux tube pairs with are either braided or unbraided. Triplet/singlet state is symmetric/antisymmetric and total asymmetry could be guaranteed by assuming symmetry/antisymmetry in spatial degrees of freedom and antisymmetry/symmetry in color degrees of freedom. This

would give anti-triplet/6-plet in color degrees of freedom. Spatial symmetry would favor antitriplet and diquark would behave like antiquark with respect to color. Let us assume antitriplet state for definiteness.

- (b) DNA codon corresponds to three-di-quark state. This state must be totally symmetric under the exchange of bosons. One can have total symmetry in both spatial and color degrees of freedom or total antisymmetry/symmetry in spatial and total antisymmetry/symmetry in color degrees of freedom. The first option gives 10-dimensional color multiplet and the second one color singlet. Braiding is maximal and symmetric/antisymmetric in these case. One can consider also mixed symmetries. In this case one has color octet which is antisymmetric with respect to the first nucleotide pair and symmetric with respect to first nucleotide pair and third nucleotide. The braiding of the first two nucleotides must be antisymmetric and the braiding of this pair with third nucleotide. The conclusion would be that color multiplets correspond to well defined braidings and one would therefore have directed connection with topological quantum computation. Color octet is especially interesting concerning the representation of color qualia.

The challenge of all these options (note that the representability of color selects quark option) is to find a good justification for why the assignment of A, T, C, G to quark states or spin states is unique dynamically. Stability argument is expected to help here.

4.4.3 Realization Of Color Qualia For Quark Option

Consider now how one could understand the generation of qualia for quark option.

1. The generation of qualia involves interaction with external world giving rise to a sensory percept. In the case of visual colors it should correspond to a measurement of quark color and should give rise to eigenstages of color at the ends of flux tubes at DNA nucleotides for a nucleus or cell of photoreceptor. A modification of capacitor model is needed. Color polarization is still essential but now polarization in nucleus or cell scale is transformed in the generation of color quale to a polarization in longer length scale by the reconnection of flux tubes so that their ends attach to “external world”. The nucleus/cell becomes color and state function reduction selects well defined quantum numbers. It is natural to assume that the entanglement in other degrees of freedom after color measurement is negentropic.
2. Does the “external world” corresponds to another cell or to the inner lipid layers of the cell membrane containing the nucleus. In the first case flux tubes would end to another cell. If the nuclei of receptor cells are integrate to a larger structure by magnetic flux sheets traversing through them one can also consider the possibility that the polarization in the scale of cell nucleus (recall that the nucleus has also double lipid layer) is transformed to a polarization in cell scale so that similar process in cell scale gives rise to qualia.

The entire receptor unit must have net color charge before the state function reduction. This requires that there are flux tubes connecting the receptor unit to a unit representing “external world” and having vanishing color charge. If second cell is the “external world” these flux tubes must go through the pair of lipid layers of both cell membrane and end up to the nucleus of cell in the environment. If external world correspond to the complement of nucleus inside cell the inner layers of cell membrane represents external world. Cell membrane indeed serves as sensory receptor in cell length scale. One can of course have sensory qualia in various length scales so that both options are probably correct and a kind of fractal hierarchy is very natural giving rise also to our qualia at some higher level. Living matter as conscious hologram metaphor suggests a fractal hierarchy of qualia.

After state function reduction reducing the entanglement the flux tubes split and the receptor becomes un-entangled with external world and has vanishing color charges. At the level of conscious experience this means that there can be only memory about the quale experience. The sensation of quale lasts with respect to subjective time as long as the negentropic entanglement prevails. There is an obvious analogy with Orch-OR (see

<http://tinyurl.com/y1fv6pp>) proposal of Hameroff and Penrose in which also conscious experience ends with state function reduction.

3. Consider now how the color qualia are generated.
 - (a) There must be two flux tube states. In the first state there are two flux tube beginning from cell nucleus A and ending to the inner lipid layer a_1 and flux tube beginning from the outer lipid layer a_2 and ending cell nucleus B. Both flux tubes have vanishing net color so that cells have vanishing net colors. This could be regarded as the resting state of the receptor. The lipids in layers a_1 and a_2 are connected by another short flux tube. Same for b_1 and b_2 .
 - (b) The second flux tube state corresponds to long flux tubes connecting the nuclei of cells A and B. The ends carry opposite color charges. In this case the net color of both A and B is non-vanishing. This state would be an outcome of a reconnection process in which the flux tubes from A to a_1 and B to a_2 re-connect with the short flux tube connecting lipid layers a_1 and a_2 .
 - (c) When these flux tubes carry opposite colors numbers at their ends, the cell possess net color charge and can represent color quale. Or rather, creation of this kind of flux tube connections would give rise to the color charging of the receptor cell with external world carrying opposite color charge.

One can argue that this mechanism is not quite in spirit with color capacitor model. Polarization is still essential but now polarization in receptor scale is transformed to polarization in longer length scale by the reconnection of flux tubes. The analog of di-electric breakdown however still applies in the sense that its analog induces large polarization. Several mechanisms generating larger polarization are of course possible. One can ask how essential the electromagnetic polarization of cell membrane is for the generation of qualia at cell level. Note also that biomolecules are quite generally polar molecules.

The unexpected prediction of the model is that braiding would correlate directly with qualia. This would mean also a connection between quantum computation and qualia. This condition emerges from Fermi/Bose-Einstein statistics correlating braiding with symmetric properties of color states and spin states. Quite generally, the correlation of braiding with the symmetries of wave functions as functions of points of braid end points would allow to have direct geometric correlate between induced entanglement and braiding as naïve intuitive expectations have suggested.

This model is not consistent with the naïve expectation that the quale is generated after state function reduction. Rather, the beginning of sensation of quale means beginning of negentropic entanglement and fusion with external world and state function usually associated with the quantum measurement would mean the end of the sensation and separation from the external world! Maybe one can say that state function reduction means that experience is replaced with a memory “I had the sensation of quale” ! Krishnamurti would certainly agree!

4.5 Flag-Manifold Qualia

Sensory mappings are basic aspect of what brain is doing and therefore one expects that this kind of mappings are performed routinely also at the level of brain. For instance, our tendency to visualize very abstract concepts as geometric objects suggests that they are indeed represented as sub-selves having definite positions inside brain (and as it seems also outside!).

I encountered this kind of mappings in rather early stage, much before the TGD inspired theory of consciousness allowed to even say much about this kind of mappings. The reason was the work of Barbara Shipman about honeybee dance [A6]. The strange findings of Shipman suggest that the color symmetry of hadron physics plays key role in sensory experiencing of the tiny honeybees, and led ultimately to the realization that classical color fields predicted by TGD are crucial for understanding visual qualia in TGD framework. Place and time coding by magnetic frequencies has been already considered in the section describing the general vision about the identification of qualia. In this section the attention will be focused to particular geometric qualia

associated with the flag manifold defined by the possible choices of the quantization axes for the super-symplectic algebra and the findings of the Barbara Shipman will be discussed in TGD framework.

4.5.1 Basic Structure Of WCW

The basic mathematical structure of quantum TGD is the infinite-dimensional space of 3-surfaces. If Kähler action were deterministic, WCW would effectively reduce to the space of 3-surfaces on the light-cone boundary $\delta M_+^4 \times CP_2$ representing the moment of big bang. The classical non-determinism of the Kähler action however forces to consider also the spaces of 3-surfaces belonging to the light-like M_+^4 projections of the light-like boundaries of the massless extremals (MEs), which are thus extremely natural geometric correlates of selves. These selves could perhaps be called light-like selves. The fact that the M_+^4 projections of CP_2 type extremal representing elementary particle is a random light-like curve, suggests strongly that one must also allow space-like 3-surfaces as correlates of selves. In this respect theory does not yet say anything definite but magnetic flux tubes are very attractive candidates (certainly not the only ones) for what might be called space-like selves.

WCW degrees of freedom can be divided into quantum fluctuating degrees of freedom and zero modes which do not quantum fluctuate (being thus “classical”) and characterize the size and shape of 3-surface and are excellent candidate for representing information about the state of organism (3-surface itself) geometrically. The zero modes of WCW are special in the sense that in each quantum jump localization occurs in these degrees of freedom.

The hypothesis is that the sequence of events leading to experience geometric qualia involves localization in (measurement of) zero modes parametrizing among other things also the possible choices of quantization axes. One cannot assign geometric qualia to the flag-manifold of the entire isometry group since the localization occurs only in zero modes: rather the sub-group generated by canonical generators labelled by even conformal weights is in question. The flag-manifold in question corresponds to the extension of canonical group of $E^2 \times CP_2$ generated by generators of even conformal weight by CP_2 local conformal transformations of light-cone boundary generated by algebra generators having even conformal weight divided by the Cartan group of $SO(2) \times SU(3)$.

One must consider also the possibility that infinite-dimensional canonical flag-manifold actually reduces (at practical level at least) to finite-dimensional flag-manifold F_3 by the requirement that the choice of the quantization axes for the super-symplectic algebra is induced by the choice of the quantization axes for color. Note that in the case of MEs the quantization axis for spin is completely fixed for $E^2 \times CP_2$ whereas for $S^2 \times CP_2$ the sphere S^2 parametrizes the choices of the quantization. Thus the flag manifold F_3 encountered by Barbara [A6] [A6] emerges naturally for MEs.

4.5.2 Quantum Honeybee

Barbara Shipman [A6] has made rather puzzling observation about the possible connection of the dance of honeybee with the color group $SU(3)$ appearing as the gauge group of strong interactions. The dance of honeybee, providing information of and depending on the distance and direction of the food source, could be regarded as a map of a certain path in the flag manifold $F_3 = SU(3)/U(1) \times U(1)$ mapped to a hexagon like plane region serving as a dance floor.

Barbara Shipman suggests a possible connection between biophysics and quantum physics at quark level. From the point of view of standard physics this suggestion looks implausible since color confinement should make dynamical effects related to color invisible above the hadronic length scale of order one fermi (10^{-9} times cellular length scale!). In TGD framework it is however possible to understand the observations of Barbara Shipman and these observations are also consistent with the general model for the universal submodalities of sensory qualia. In fact, the work of Barbara Shipman served as an important impetus during the process leading to the general TGD based model of sensory qualia.

Dance of the honeybee

The dance of the honeybee occurs at the vertical face of the honeycomb and codes the information about the distance and direction of the food source. Von Frisch discovered the choreographic syntax and interpretation of the dance and published the results of his work in his 1967 book “Dance language and Orientation of Bees” [J122].

The pattern of the dance is that of figure eight above certain critical distance to the food source and that of a circle below this distance.

1. The angle of the figure eight pattern with respect to the vertical codes the angle between the direction of the food source and the horizontal projection of Sun. For instance, when the food source is in the direction of Sun, figure eight pattern is vertical. The dancer waggles and produces buzzing sound during the first phase of the dance and then walks to the original position along the other circle of the figure eight. After that the dancer waggles again but now along the second circle of the figure eight so that the wagging phases of the dance form the pattern of a figure V in the middle of the figure 8. The buzzing sound produced by the wings of the dancer makes it possible for the audience to locate the dancer (dance occurs in darkness). The opening angle of the figure V codes the distance to the food source for distances above some critical distance.
2. Below the critical distance the pattern changes to a circle. Now the wagging parts of the dance correspond to two disjoint straight line portions located at the opposite sides of the hexagon.

What Barbara Shipman found [A6] was that the images of certain curves of 6-dimensional flag manifold under the so called momentum map reproduce the dancing pattern of the honeybee if the six initial values determining the curve are chosen suitably. Only two of these parameters code the information about the food source. The article about the model of honeybee dance is not published yet but on the basis of short abstract [A6] it is very plausible that the curves in question are solution curves associated with a completely integrable system known as a full Kostant-Toda lattice studied by Barbara Shipman [A7, A8]. The solutions of the $2(n - 1)$ equations of motion associated with this model can be mapped to the solutions of certain completely integrable Hamiltonian system in the flag manifold $F_n = SL(n, C)/B$, where $SL(n, C)$ is the space of complex matrices with unit determinant and B is the space of upper triangular matrices with unit determinant. F_n is in turn isomorphic with $SU(n)/U(1)^n$ and this implies a connection with the quantum measurement theory of color charges in $n = 3$ case.

The dance of honeybee should somehow map the some curve of the flag-manifold to a planar curve representing the dancing pattern. $SU(n)$ acts as Hamiltonian transformations of the flag manifold but not as symmetries of Kostant-Toda lattice: in particular, the Cartan algebra generators define Hamiltonians $H_I(x)$ and $H_Y(x)$ in F_3 . The so called momentum map associating to the point x of the flag manifold F_3 the point $(H_I(x), H_Y(x))$ characterizing the values of the isospin and hypercharge Hamiltonians at the point x . The image of F_3 under this map is hexagonal region of plane and the image of Kostant-Toda orbit under this map is identified as the dancing pattern of the honeybee. It is obvious that $SU(3)$ cannot act as symmetries of the Kostant-Toda system since in this case Hamiltonians would be constant along the solution curves and momentum map would map every orbit to single point.

To summarize the result concisely:

1. If the orbit of 3-surface in the flag manifold is characterized by Hamiltonian equations related to the so called Kostant-Toda lattice, which is a completely integrable system,
2. if the hexagonal planar region defined by the image of the momentum map corresponds to the “dance floor” and
3. if the orbit of the bee corresponds to the image of the orbit of flag manifold under the momentum momentum map,

one can understand the basic aspects of the waggle dance.

One can indeed understand the dance of honeybee as a representation for the information content of thought of the honeybee. What forces one to take the model seriously is that it reproduces also the dependence of the dancing pattern on bee community and predicts correctly the spectacular change of the V shaped dancing pattern to a union two disjoint lines on the opposite boundaries of the hexagon like region.

TGD based model of the honeybee dance

The concept of self and the TGD based model for sensory experiencing lead directly to the prediction that mental images, also those of tiny honeybee, should correspond to almost continuous curves of infinite-dimensional flag-manifold containing F_3 as sub-flag-manifold. If these orbits are solution curves of dynamical system defined by Kostant-Toda lattice, one can understand the observations of Barbara Shipman.

1. Why curves in flag-manifold?

1. Flag manifold F_3 characterizes especially interesting zero modes. If the contents of the sensory experience is determined by the localization in zero modes occurring in quantum jump, the coordinates of F_3 for mind like space-time sheet generated in sensory perception and representing object of perceptive field, should code some basic data about sensory experience. Since F_3 represents geometric qualia, it is associated with all senses, not only vision and that this role might be similar for all sensory qualia.
2. F_3 is indeed identical with the flag manifold $SL(3, C)/B$ studied by Barbara Shipman. The dimension of $SU(n)/H$, $H = U(1)^{n-1}$, is $D = n(n-1)$ and same as the dimension of the flag-manifold and In $n = 2$ case the two spaces are identical as direct inspection shows. In the general case the isomorphy follows from the observation that arbitrary $SL(n, C)$ matrix s can be expressed as a product $s = b_1 u$, where u is $SU(n)$ matrix and b_1 belongs to the group $B_1 \subset B$ of the upper diagonal matrices with real elements on the diagonal. The elements of B in turn are expressible in the form $b = b_1 h$, where h is diagonal matrix belonging to Cartan group and b_1 belonging to B_1 . Therefore the flag manifold can be written as $F = SL(n, C)/B = B_1 SU(n)/B_1 H = SU(n)/H$.
3. Time development by quantum jumps means hopping in zero modes and since the increment of the geometric time in single quantum jump is expected to be very short, of order 10^4 Planck times, the time development should define an almost continuous curve in F_3 . In particular, subjective memory of self about quantum jump sequence corresponds to curve in F_3 defined by the averaged increments of zero modes represented by sub-selves.
4. In the ideal case honeybee could code the coordinates and velocities for entire fly path to the food source but this kind of feat is impossible even for us. In practice only the distance and direction of the food source is needed. This information must correspond to sub-self of the honeybee and sub-self in turn corresponds a curve of the flag-manifold F_3 . If the projection of this orbit to F_3 is determined by the dynamics of a completely integrable system known as full Kostant-Toda lattice, the physical foundations for the model of Barbara Shipman can be understood in TGD framework.

2. Why the projection of flag-manifold curve to hexagonal plane region

A possible explanation for the reduction of the path to a two-dimensional path is based on the following observations.

1. The simplest extremals of Kähler action have 2-dimensional CP_2 at a geodesic sphere of CP_2 , which can be homologically non-trivial or trivial. For the first option classical electromagnetic and W fields are non-vanishing. For the latter option electromagnetic and Z^0 fields are non-vanishing and proportional to each other. Almost vacuum extremals provide a detailed model for both sensory receptor and basic sensory qualia and will be discussed at the end of the chapter whereas far from vacuum extremals seem to provide a model for magnetic bodies. Also the simplest MEs can be classified to these two types.

2. The holonomy algebra of color group is Abelian and one can gauge rotate the color gauge algebra to some $U(1) \times U(1)$ subalgebra of $SU(3)$ and two CP_2 coordinates can serve as the coordinates of these space-time surfaces. Also the dance floor of honeybee can be coordinatized by two CP_2 coordinates.
3. Each space-time surface has by topological field quantization a unique Cartan algebra $U(1) \times U(1)$. Since the values of the color Hamiltonians are well defined functions in CP_2 , a very natural choice for the two coordinates is as Hamiltonians H_I and H_Y appearing also as the coordinates of the dance floor in Shipman's model. The region defined by H_I and H_Y has the hexagonal shape and since its boundaries naturally correspond to the boundaries of a mind like space-time sheet such as ME, the mapping of the sequence of increments of flag-manifold coordinates to space-time sheet to a curve inside diffeomorph of the hexagon in plane looks natural. It seems that honeybee really experiences these coordinates directly as imagined positions in plane.

3. How flag-manifolds emerge from first principles?

A deeper explanation for flag-manifold emerges in zero energy ontology combined with the hierarchy of Planck constants.

1. Zero energy states correspond to entangled pairs of positive and negative energy states located at the opposite light-like boundaries of a given causal diamond (CD) defined as the intersection of future and past directed light-cones. Strictly speaking a Cartesian product of CD with CP_2 is in question. CDs form a fractal hierarchy. In the ordinary ontology zero energy state corresponds to a physical event. The time-like entanglement between positive and negative energy states defines M -matrix generalizing the notion of S-matrix. Time-like entanglement must be fundamental also from the point of view of consciousness as a reduction of quantum state to a state with well defined values of observables for the initial (positive energy) and final (negative energy) states. The Cartesian product of causal diamond CD defined as the intersection of future and past directed light cones with CP_2 . CD is characterized by the positions of its tips so that one has M^4 valued cm coordinate plus relative coordinate between the tips. p-Adic length scale hypothesis follows if the proper time distance is quantized in powers of two. This suggests that also the of the tip at the hyperboloid with constant proper time is discrete and that discrete lattice like structure defined by some discrete subgroup of $SL(2, C)$ acting as boosts on given reference CD.
2. The hierarchy of Planck constants forces a generalization of the embedding space to a book like structure [K47, K45, K43, K23, K24]. The pages of the Big Book are characterized by two numbers x_a and x_b assignable to M^4 and CP_2 degrees of freedom. The values of these numbers are either integers or their inverses depending on whether the page of the book is a singular covering or factor space defined by a discrete subgroup of $SU(2)$. For a given CD the sectors characterized by different integers are glued together along $M^2 \subset M^4$ defining quantization axis of energy and spin. In CP_2 degrees of freedom the gluing is along a homologically trivial geodesic sphere of CP_2 and also now a fixing of the quantization axes is involved. The positions of the tips of CD and preferred points of CP_2 at the two light-like boundaries of CD fix the quantization axis and moduli space for CDs. An attractive hypothesis is that the relative positions of tips and corresponding preferred points of CP_2 form discrete spaces. The quantization of the temporal distance between tips in powers of two implies p-adic length scale hypothesis.
3. The tips of CD define a preferred time coordinate, which together with M^2 defines the quantization axes of energy and spin. In the case of CP_2 has also a choice of color and isospin quantization axes implied by the choice of a pair of CP_2 points and the choice of S^2 . This means that one has a flag-manifold defined by the choices of quantization axes for energy and momentum one one hand and for color quantum numbers on the other hand. Therefore the model for the honeybee dance finds a justification from the first principles of quantum TGD.

4. Why solutions of full Kostant-Toda lattice?

The hexagonal shape of the dance floor is very strong qualitative prediction as such involving no dynamical models and the attempt to reduce the dynamics to Kostant-Toda lattice might be more than one can desire. Certainly so, if honeybee represents its memories about entire non-deterministic path to the food source rather than just the minimum data abstracted from what honeybee remembers. Of course, honeybee dance might represent only the minimum information making possible to find the food source and this would be achieved if dance represents a deterministic dynamical system with a very high symmetry. Thus it makes sense to ask why just the solution curves of full Kostant-Toda lattice should approximate the almost continuous orbit of F_3 defined by quantum jump sequence summarizing the memories of honeybee.

1. A possible explanation is that the mental images of the honeybee are result of long evolution and self organization and that mental images with standardized content such as position of the food source, correspond to a solution of some very symmetrical dynamical system.
2. That the full Kostant-Toda lattice is needed can be partially understood. For the full Kostant-Toda lattice time evolution is not unitary transformation but similarity and $SU(3)$ does not in general act as symmetries: if this were the case Cartan group associated with the 3-surface would be a constant of motion. Rather, the eigenvalues of the traceless $SL(3, \mathbb{C})$ Lie-algebra matrix S (see appendix) are the needed two complex constants of motion. For instance, geodesic motion in flag manifold would have $SU(3)$ as symmetries and this would imply that Cartan algebra would define constants of motion and the momentum map would map the orbits to the points of plane. The breaking of $SU(3)$ symmetry is natural since also quantum jump sequence defining the memory of honeybee represents sequence of changes of color quantization axes.

Questions

There are several questions to be answered.

1. The representation curve in F_3 is determined by the initial values of six coordinates. The information coded into the dance fixes only two coordinates and the initial values of the remaining coordinates must be constants specific to hive or subspecies of honey bees. It would not be surprising that these parameters are somehow complementary to the 2 complex constants of motion (eigenvalues of S) associated with the Kostant-Toda dynamics.
2. Somehow the direction of food source and its distance should be coded into the initial values: perhaps the initial values of the flag manifold point develop in time during the flight of the honeybee from the food source to the nest according to a simple rule from initial values corresponding to vanishing distance and ill defined direction angle. The flight occurs along a straight line so that this mechanism looks plausible.
3. For the information to become properly interpreted, the dance should generate the original representation of the information as a flag manifold orbit in the minds of the audience. This requires that the direction with respect to vertical and opening angle are mapped to the initial values of the flag manifold orbit. One can also consider possibility is that the orbit of the flag manifold provides a mental representation for the shortest path to the food source. Magnetic fields are known to be important for the ability of the bee to fly in straight line and the fact that magnetic fields give rise to color magnetic fields suggests that quantum measurement of color charges during the flight might be an important factor in the orienteering of the honeybee. Perhaps the comparison of the measured real color charges with the measured color charges in the mental representation of the orbit is involved.

Some mathematical background

1. Complete Kostant-Toda lattice

Completely integrable systems [B4] allow quite generally a Hamiltonian formulation such that there exist maximal number of constants of motion in involution (having vanishing Poisson brackets). This makes the quantization of the completely integrable systems possible. The so called

Lax pair allows to transform the dynamics of completely integrable systems to a time dependent unitary transformation of some tensorial or spinorial quantity and this leads to the so called inverse scattering method allowing to solve completely integrable models.

An example of a finite-dimensional completely integrable system is provided by the so called Toda lattice consisting of $n - 1$ lattice points on line (one can formally add the point at $Q_n = \infty$ to make equations more symmetrical. To each lattice point $a = 1, \dots, n$ a coordinate variable Q^a is attached. The interaction potential is non-vanishing for the nearest neighbors only and has exponential dependence on the coordinate difference $Q^a - Q^b$. The Hamiltonian of the system can be written as

$$H = \sum_{a=1}^n \left[\frac{1}{2} (P^a)^2 + \exp(-Q^{a+1} + Q^a) \right] . \quad (4.5.1)$$

Toda equations allow group theoretical interpretation [B4] . The change of variables $q^a = Q^a - Q^{a-1}$ allows to cast the Lagrangian associated with the action into the form

$$L = \frac{1}{2} \sum_{a,b=1}^{n-1} \frac{dq^a}{dt} K_{ab}^{-1} \frac{dq^b}{dt} - \sum_{a=1}^{n-1} \exp(-q_a) . \quad (4.5.2)$$

The equations of motion for S read as

$$\frac{dS}{dt} - [S, U] = \frac{1}{2} \sum_{a,b=1}^{n-1} H_a K_{ab}^{-1} \left[\frac{d^2 q^b}{dt^2} - \sum_{c=1}^{n-1} K_{bc} \exp(-q_c) \right] = 0 , \quad (4.5.3)$$

and by the unitarity requirement are equivalent with the original equations of motion for the Toda lattice.

The Lax pair of the so called full Kostant-Toda lattice (presumably relevant to the model of the dance of honeybee) is defined in the following manner (for a detailed and very technical description see the articles [A7, A8]). The dynamical variable S belongs to the space $B_- + \varepsilon$ of matrices belonging to $SL(n, C)$ Lie algebra. ε is a matrix having units only above the diagonal: $\varepsilon_{ij} = \delta_{j,i+1}$. B_- consists of the lower triangular matrices with trace zero. The equations of motion read

$$\begin{aligned} \frac{dS}{dt} &= i[H, S] , \\ S &= b_- + \varepsilon , \\ H &= \Pi_{N_-} S . \end{aligned} \quad (4.5.4)$$

$H = \Pi_{N_-} S$ is the strictly lower triangular part of S , which is nilpotent, and acts as a non-hermitian Hamiltonian in the quantum form of the equations of motion. The time development is not unitary but corresponds to a similarity preserving the eigenvalues of S , which in fact define $2(n - 1)$ constants of motion.

There exists a natural embedding of the space $B_- + \varepsilon$ to the flag manifold $F_n = SL(n, C)/B$, where B consists of upper diagonal matrices with units in diagonal. The mapping is obtained by first identifying $B_- + \varepsilon$ with B_- and then noticing that the complement of B_- represent the Lie-algebra elements of $Sl(2, C)$ modulo matrices having upper triangular part with vanishing diagonal elements. The standard exponential mapping of Lie-algebra to the group maps B_- to $Sl(n, C)/B$. The equations of motion in F_n reduce to Hamiltonian equations of motion generated by the Hamiltonian $H = \frac{1}{2} Tr(S^2)$ [A8]. The simplest constants of motion are the eigenvalues of the matrix S and give four constants of motion. In the case of $SL(n, C)$ the eigenvalues span the space C^{n-1} .

$SL(n, C)$ Cartan algebra action induces Hamiltonian flow in the flag manifold and one can associate with the $SU(n)$ Cartan algebra Hamiltonian functions $H_i(x)$, $i = 1, \dots, n-1$ defined in the

entire flag manifold. Since Konstant-Toda dynamics is not unitary, the Cartan algebra of $SU(n)$ does not act as symmetries and the corresponding Hamiltonians are not constants of motion. The Toda flows associated with the diagonal traceless matrices are trivial so that the points in the image of C^{n-1} are fixed points of the Hamiltonian evolution associated with the Cartan algebra. The level sets of the Kostant-Toda Hamiltonian consist of unions of $(n-1)$ -dimensional complex tori.

The values H_1, H_2, \dots, H_{n-1} of the compact Cartan algebra Hamiltonians at given point x of the flag manifold F_n define a map of the flag manifold to $(n-1)$ -dimensional convex polytope known as momentum map. For $n=3$ the polytope is hexagon. Since the solutions of the Toda equations correspond to certain curves in flag manifold they are mapped to curves inside this hexagon. If Cartan algebra would act as symmetries, the momentum map would map the flag manifold to a single point.

2. Flag manifold F_3 from topological field quantization

A less general manner to end up with the flag-manifold concept is based on what I call topological field quantization. The first approach is certainly more attractive in its generality and by its close relationship with the basic concepts of TGD inspired theory of consciousness (entanglement has interpretation as attention in TGD inspired theory of consciousness) and topological field quantization could at best provide a concrete realization of the picture based on the quantum measurement theory.

1. Topological field quantization corresponds to the formation of 3-surfaces of a finite spatial size with a choice of a preferred “quantization axes” for rotations (say z-axis) and color hyper charge and color isospin. One can express the angle coordinates Ψ and Φ associated with hyper charge and isospin in terms of the angle coordinate ϕ associated with the rotations around z-axis as

$$\begin{aligned}\Psi &= n_1\phi + k_1z + \text{Fourier expansion} \\ \Phi &= n_2\phi + k_2z + \text{Fourier expansion}\end{aligned}$$

n_1 and n_2 are almost topological quantum numbers expressing the change of angles Ψ and Φ in a rotation around z-axis. In the case of non-vacuum space-time sheets one can say that there are hypercharge and isospin currents rotating in the direction of ϕ . The choice of the hyper charge and isospin quantization axes leads naturally to the possibility to associate to a given 3-surface a point of the flag manifold encountered in the work of Barbara Shipman.

2. The requirement that the Cartan group H fixing the quantization axes corresponds to the subgroup of $SU(3)$ determined by quantum entanglement fixes uniquely topological field quantization and implies the equivalence of the topological field quantization approach with the picture based on quantum measurement theory.
3. The choice of the quantization axes with constant values of n_i over the entire 3-surface is *not* possible for an arbitrary 3-surface globally: rather the 3-surface decomposes into several regions with varying values of n_i . It might however happen that only 3-surfaces consisting of only single region are dynamically stable. On the other hand, the assumption that the choice is global in general fixes the choice uniquely since small change in the direction of the rotational quantization axes implies that a region where the change of angle variable around closed curve around the new z-axes is trivial. Same applies to the change of quantization axes in color degrees of freedom. Note however that for a general closed curve around z-axes, small change in the direction of quantization axes does not change the value of the phase increment. When 3-surface allows global choice of n_i , one can associate to the 3-surface a unique point of the flag manifold. Physical intuition suggests that this point is same as that determined by the quantum entanglement. In the general case one can decompose the 3-surface into several regions, such that each of them has different values of topological quantum numbers for a given choice of quantization axes. It is tempting to interpret the maximal region with fixed values of n_i as a maximal sub-system for which it makes sense to perform the measurement of color charges with given quantization axes.

4.5.3 Quantum Honeybee And DNA As Topological Quantum Computer

The model for the dance of honeybee was an idea before its time and remained in a dormant state for several years. The increased understanding of quantum TGD proper making possible to develop a model for how DNA could act as a topological quantum computer eventually provided a fresh perspective to the problem.

The progress in understanding of quantum TGD

It is appropriate to make a list of new concepts and ideas which are prerequisites for the model of DNA as topological quantum computer.

“The world of classical worlds” can be identified as the space of light-like 3-surfaces identifiable also as partonic orbits with dynamics which is not completely deterministic so that 3-dimensionality in discretized sense and local effective 2-dimensionality are obtained [K31]. A considerable generalization of the conformal symmetries of string models and a formulation of quantum TGD as almost topological quantum field theory emerged.

2. The evidence that planetary orbits are identifiable as Bohr orbits led to a generalization of the notion of embedding space obtained by replacing it with a union of infinite number of sectors labeled by different values of Planck constant [K111, K85, K47]. The generalization explains dark matter as phases in which Planck constant differs from its value for the visible matter (visible to us, the notion of darkness is relative). Phases of matter with arbitrarily large values of Planck constant are predicted and give rise to macroscopic quantum phases even in astrophysical length scales. These phases are especially important in living matter. The value of Planck constant characterizes topological field quanta serving as space-time correlates for the interactions between particles. Dark matter residing at magnetic flux quanta of field body having large value Planck constant would be responsible quantum control of living matter [K13, K44]. Magnetic body would have an onion like structure consisting of layers with increasing value of Planck constant. The highest layer determines the evolutionary level of system and great leaps in evolution would correspond to the emergence of a new layer with larger value of \hbar to the magnetic body.
3. A more precise characterization for the fundamental notion of quantum criticality emerges from the generalization of the notion of embedding space. The sectors intersect along $M^4 \times S^2$ and $M^2 \times CP_2$ and maximal quantum criticality corresponds to $M^2 \times S^2$. The geodesic sphere S^2 of CP_2 with trivial homology plays key role in this picture and vacuum extremals $X^4 \subset M^4 \times S^2$ define one particular example of quantum critical surfaces. The isometries of S^2 correspond to $SO(3) \subset SU(3)$. Notice that the flag manifold $F = SU(3)/U(1) \times U(1)$ reduces naturally to $F_{red} = SO(3)/U(1) = S^2$ for almost vacuum extremals.
4. In TGD positive energy ontology must be replaced with what I have christened zero energy ontology [K31, K30]. In zero energy ontology physical states correspond to zero energy states decomposable to pairs of positive and negative energy states localizable at the future and past directed boundaries of a pair of light cones forming a causal diamond. Zero energy ontology allows to identify time-like entanglement coefficients - M-matrix - as a “complex square root” of the density matrix decomposing to a product of positive square root of density matrix and unitary S-matrix so that thermodynamics becomes part of quantum theory.
5. Von Neumann algebras known as hyper-finite factors of type II₁ [K141, K47] play a fundamental role in the formulation of quantum TGD [K31, K30]. This means a profound deviation from standard quantum field theories and ordinary quantum mechanics. The notion of quantum group whose physical interpretation has remained poorly understood represents a key aspect of this difference. Finite measurement resolution [K30] becomes the key notion of the quantum measurement theory in this framework. It can be represented as an inclusion of von Neumann algebras with included algebra defining the measurement resolution. More concretely, complex rays of state space are replaced with sub-spaces generated by the included algebra and the Hermitian elements of this algebra represent symmetries of the M-matrix.

These enormous symmetries allow to fix the possible M-matrices highly uniquely in terms of Connes tensor product. Thus the mere fact that measurement resolution is finite fixes the quantum dynamics of the theory almost completely and leads to a new kind of description of coupling constant evolution allowing also to understand the origin of p-adic length scale hypothesis.

General model for DNA as topological quantum computer

The progress in the understanding of quantum TGD led to various biological applications. The presence of dark matter with the properties predicted by TGD can be deduced from the strange findings about the behavior of cell membrane [I125]. These properties are not quite the same as they are believed to be: dark matter has classical interactions with ordinary matter - in particular electromagnetic interactions - but only particles with same value of \hbar (belonging to same sector of embedding space) can appear in interaction vertices. This is enough to achieve consistency with what is really known about dark matter. Detailed models for nerve pulse [K96] and EEG [K44] emerge. One of the most fascinating applications is the model of DNA - cell membrane system as a topological quantum computer (TQC) [K3]: this model leads to a further insights about findings of Shipman.

1. The model for DNA as topological quantum computer [K3] assumes that magnetic flux tubes connecting DNA nucleotides to lipids of nuclear/cell membrane define braid strands. To be precise, wormhole magnetic fields consisting of two parallel magnetic flux tubes with opposite fluxes are in question. Wormhole magnetic flux tubes have at their ends wormhole contacts with quark and antiquark at their throats (these defining light-like 3-surfaces) [K145]. Braid strands are “colored” and the four colors correspond to the four nucleotides A, G, T, C. Coloring corresponds physically to a map of nucleotides to quarks u, d and their antiquarks at the upper throat of wormhole contact at the DNA end of wormhole magnetic field (second end contains the conjugate of this state). Kind of 1-1 genetic code is in question and has profound implications for the understanding of the selectivity of bio-catalysis. Quarks have large \hbar and obey a scaled up variant of QCD like dynamics. Note that in this framework the proposal of Barbara Shipman that quarks are involved with honeybee dance begins to make sense.
2. Tqc program is coded by the “dance” of lipids defining a time-like braiding. Since the lipids are connected to nucleotides, their dance defines also space-like braiding coding TQC program to memory: an extremely general mechanism of memory storage is in question which might been present already during pre-biotic era. The braiding is generated by the motion of lipids in liquid crystal phase forced by the motion of cellular water in gel phase because the hydrophobic ends of lipids are anchored to the moving water molecules. Dissipation in the presence of metabolic energy feed means that the liquid flow approaches to an asymptotic self organization pattern depending only weakly on the initial conditions: the interpretation is as a Darwinian selection of TQC programs. There is actually a fractal hierarchy of TQC programs and each sub-program appears as an ensemble of similar copies so that TQC gives automatically probability distributions as an outcome represented as a four-dimensional pattern of classical fields and various rates (chemical rates, firing rates for nerve pulses, ...).
3. The basic braiding operation - a twist permuting the position of lipids- defines the universal 2-gate. Besides this 1-gates are needed and $SU(2)$ rotation is enough. Here one can consider several candidates: since quarks and antiquarks are in crucial role in TQC, one of them corresponds to color $SU(3)$ or its subgroup. This could explain the mysterious looking discovery of Barbara Shipman. This aspect is described in more detail below.

Realization of 1-gates of TQC in terms of color rotations and connection with honey-bee dance

The realization of single particle gates as $U(2)$ transformations leads naturally to the extension of the braid group by assigning to the strands sequences of group elements satisfying the group multiplication rules. The group elements associated with a n^{th} strand commute with the generators

of braid group which do not act on n^{th} strand. G would be naturally subgroup of the covering group of rotation group acting in spin degrees of spin 1/2 object. Since $U(1)$ transformations generate only an overall phase to the state, the presence of this factor might not be necessary. A possible candidate for $U(1)$ factor is as a rotation induced by a time-like parallel translation defined by the electromagnetic scalar potential $\Phi = A_t$.

One of the challenges is the realization of single particle gates representing $U(2)$ rotation of the qubit. The first thing to come mind was that $U(2)$ corresponds to $U(2)$ rotation induced by magnetic field and electric fields. A more elegant realization is in terms of $SU(3)$ rotation, where $SU(3)$ is color group associated with strong interactions and this suggests connection with the findings of Shipman.

1. The realization of qubit as ordinary spin

A possible realization for single particle gate $s \in SU(2)$ would be as $SU(2)$ rotation induced by a magnetic pulse. This transformation is fixed by the rotation axis and rotation angle around this axes. This kind of transformation would result by applying to the strand a magnetic pulse with magnetic field in the direction of rotation axes. The duration of the pulse determines the rotation angle. Pulse could be created by bringing a magnetic flux tube to the system, letting it act for the required time, and moving it away. $U(1)$ phase factor could result from the electromagnetic gauge potential as a non-integrable phase factor $\exp(i e \int A_t dt / \hbar)$ coming from the presence of scale potential $\Phi = A_t$ in the Hamiltonian.

One can criticize this model. The introduction of magnetic pulses does not look an attractive idea and seems to require additional structures besides magnetic flux tubes (MEs?). It would be much nicer to assign the magnetic field with the flux tubes defining the braid strands. The rotation of magnetic field would however require changing the direction of braid strands. This does not look natural. Could one do without this rotation by identifying spin like degree of freedom in some other manner? This is indeed possible.

2. The realization of 1-gate in terms of color rotations

TGD predicts a hierarchy of copies of scaled up variants of both weak and color interactions and these play a key role in TGD inspired model of living matter. Both weak isospin and color isospin could be considered as alternatives for the ordinary spin as a realization of qubit in TGD framework. Below color isospin is discussed but one could consider also a realization in terms of nuclei and their exotic counterparts [L3], [L3] differing only by the replacement of neutral color bond between nuclei of nuclear string with a charged one. Charge entanglement between nuclei would guarantee overall charge conservation.

1. Each space-time sheet of braid strands contains quark and antiquark at its ends. Color isospin and hypercharge label their states. Two of the quarks of the color triplet form doublet with respect to color isospin and the third is singlet and has different hyper charge Y . Hence qubit could be realized in terms of color isospin I_3 instead of ordinary spin but third quark would be inert in the Boolean sense. Qubit could be also replaced with qutrit and isospin singlet could be identified as a statement with ill-defined truth value. Trits are used also in ordinary computers. In TGD framework finite measurement resolution implies fuzzy qubits and the third state might relate to this fuzziness. Note that hyper-charge would induce naturally the $U(1)$ factor affecting the over all phase of qubit but affecting differently to the third quark.
2. Magnetic flux tubes are also color magnetic flux tubes carrying non-vanishing classical color gauge field in the case that they are non-vacuum extremals. The holonomy group of classical color field is an Abelian subgroup of the $U(1) \times U(1)$ Cartan subgroup of color group. Classical color magnetic field defines the choice of quantization axes for color quantum numbers. For instance, magnetic moment is replaced with color magnetic moment and this replacement is in key role in simple model for color magnetic spin spin splittings between spin 0 and 1 mesons as well as spin 1/2 and 3/2 baryons.
3. There is a symmetry breaking of color symmetry to subgroup $U(1)_{I_3} \times U(1)_Y$ and color singletness is in TGD framework replaced by a weaker condition stating that physical states have vanishing net color quantum numbers. This makes possible the measurement of color quantum numbers in the manner similar to that for spin. For instance, color singlet formed

by quark and antiquark with opposite color quantum numbers can in the measurement of color quantum numbers of quark reduce to a state in which quark has definite color quantum numbers. This state is a superposition of states with vanishing Y and I_3 in color singlet and color octet representations. Strong form of color confinement would not allow this kind of measurement. The almost vacuum extremal property suggests also the reduction of $SU(3)$ to $SO(3)$ with ensuing reduction of F to S^2 .

4. Color rotation in general changes the directions of quantization axis of I_3 and Y and generates a new state basis. Since $U(1) \times U(1)$ leaves the state basis invariant, the space defined by the choices of quantization axes is 6-dimensional flag manifold $F = SU(3)/U(1) \times U(1)$. The original belief was that -in contrast to standard model- color rotations in general do not leave classical electromagnetic field invariant. There are however good arguments based on the Abelian holonomy of the classical gluon fields showing that color rotation only induces an Abelian gauge transformation so that the induced gauge field remains a superposition of gauge transformed em field and W boson field *resp.* em field and Z^0 field corresponding to the two kinds of geodesic spheres. This also conforms with the general vision about electro-weak symmetry breaking taking place already at the level of CP_2 geometry. Hence color rotations are not visible at the level of classical interactions as was the original belief inspiring the idea that color rotation would affect the resting potential of cell membrane and have thus a direct neuronal correlate.
5. If color isospin defines the qubit or qutrit in topological quantum computation, color quantum numbers and the flag manifold F should have direct relevance for cognition. If nearly vacuum extremals are involved one might understand also the reduction of parameters from 6 to two as the effective replacement of F with $S^2 = SO(3)/SO(2)$; this is actually rather natural if the information communicated is the 2-D coordinates of the food source. Color rotations of the lipid ends of the magnetic flux tubes would define 1-gates representing this geometric information. Subsequent state function reduction would provide conscious representations in terms of trits characterizing for instance sensory input symbolically.

To sum up, this picture suggests that 1-gates of DNA topological quantum computation (understood as “dance of lipids”) are defined by color rotations of the ends of space-like braid strands and at lipids. The color rotations would be induced by sensory and other inputs to the system. Topological quantum computation would be directly related to conscious experience and sensory and other inputs would fix the directions of the color magnetic fields. The findings of Barbara Shipman give support this picture.

4.6 A General Model For Qualia And Sensory Receptor

Various sensory qualia correspond to the average increments of quantum numbers for a quite long sequence of quantum jumps. Quantum numbers could be spin, momentum, energy, electromagnetic charge, color quantum numbers (isospin and hypercharge in a constant proportion), various particle numbers, etc... What happens in the sensory receptors is that the gradient of some physical quantity is transformed to average increments of appropriate quantum numbers responsible for the quale representing the gradient of the physical quantity. Spatial gradients are transformed first to temporal gradients by a process, which is essentially scanning (say saccadic motion). Temporal gradients are then transformed to non-vanishing average increments of appropriate charges per quantum jump in a long sequence of quantum jumps. The problem is to understand how this process is realized at the level of sensory receptors.

4.6.1 A General Model Of Qualia

It is good to start by summarizing the general vision about sensory qualia and geometric qualia in TGD Universe.

1. The basic assumption is that sensory qualia correspond to increments of various quantum numbers in quantum jump. Standard model quantum numbers- color quantum numbers,

electromagnetic charge and weak isospin, and spin are the most obvious candidates. Also cyclotron transitions changing the integer characterizing cyclotron state could correspond to some kind of quale- perhaps “a feeling of existence”. This could make sense for the qualia of the magnetic body.

2. Geometric qualia could correspond to the increments of zero modes characterizing the induced CP_2 Kähler form of the partonic 2-surface and of the moduli characterizing the causal diamonds serving as geometric correlates of selves. This moduli space involves the position of CD and the relative position of tips as well as position in CP_2 and relative position of two CP_2 points assigned to the future and past boundaries of CD. There are good motivations for proposing that the relative positions are quantized. This gives as a special case the quantization of the scale of CD in powers of two. Position and orientation sense could represent this kind of qualia. Also kinematical qualia like sensation of acceleration could correspond to geometric qualia in generalized 4-D sense. For instance, the sensation about motion could be coded by Lorentz boosts of sub-CD representing mental image about the object.
3. One can in principle distinguish between qualia assignable to the biological body (sensory receptors in particular) and magnetic body. The basic question is whether sensory qualia can be assigned only with the sensory receptors or with sensory pathways or with both. Geometric qualia might be assignable to the magnetic body and could provide third person perspective as a geometric and kinematical map of the body and its state of motion represented using the moduli space assignable to causal diamonds (CD). This map could be provided also by the body in which case the magnetic body would only share various mental images. The simplest starting assumption consistent with neuro-science is that sensory qualia are assigned with the cell membrane of sensory receptor and perhaps also with the neurons receiving data from it carried by Josephson radiation coding for the qualia and possibly partially regenerating them if the receiving neuron has same value of membrane potential as the sensory receptor when active. Note that during nerve pulse also this values of membrane potential is achieved for some time.

4.6.2 Detailed Model For The Qualia

The proposed vision about qualia requires a lot of new physics provided by TGD. What leads to a highly unique proposal is the intriguing coincidence of fundamental elementary particle time scales with basic time scales of biology and neuro science and the model of DNA as topological quantum computer [K3].

1. Zero energy ontology brings in the size scale of CD assignable to the field body of the elementary particle. Zero energy states with negentropic time-like entanglement between positive and negative energy parts of the state might provide a key piece of the puzzle. The negentropic entanglement between positive energy parts of the states associated with the sub-CD assignable to the cell membrane and sub-CD at the magnetic body is expected to be an important factor.
2. For the standard value of \hbar the basic prediction would be 1 ms second time scale of d quark, 6.5 ms time scale of u quark, and 1 second time scale of electron as basic characterizes of sensory experience if one accept the most recent estimates $m(u) = 2$ MeV and $m(d) = 5$ MeV for the quark masses [C3]. These time scales correspond to 10 Hz, 160 Hz, and 1280 Hz frequencies, which all characterize neural activity (for the identification of 160 Hz frequency as cerebellar resonance frequency see [J51]). Hence quarks could be the most interesting particles as far as qualia are considered and the first working hypothesis would be that the fundamental quantum number increments correspond to those for quark-anti-quark pair. The identification in terms of quantum numbers of single quark is inconsistent with the model of color qualia.
3. The model of DNA as topological quantum computer led to the proposal that DNA nucleotides are connected to the lipids of the cell membrane by magnetic flux tubes having quark and antiquark at its ends such that the u and d quarks and their antiquarks code for

the four nucleotides. The outer lipid layer was also assumed to be connected by flux tubes to the nucleotide in some other cell or in cell itself.

4. The model for DNA as topological quantum computer did not completely specify whether the flux tubes are ordinary flux tubes or wormhole flux tubes with possibly opposite signs of energy assigned with the members of the flux tube pair. Although it is not necessary, one could assume that the quantum numbers of the two parallel flux tubes cancel each other so that wormhole flux tube would be characterized by quantum numbers of quark pairs at its ends. It is not even necessary to assume that the net quantum numbers of the flux tubes vanish. Color confinement however suggests that the color quantum at the opposite ends of the flux tube are of opposite sign.
 - (a) The absence of a flux tube between lipid layers was interpreted as an isolation from external world during the topological quantum computation. The emergence of the flux tube connection means halting of topological quantum computation. The flux tube connection with the external world corresponds to sensory perception at the level of DNA nucleotide in consistency with the idea that DNA plays the role of the brain of cell [K103]. The total color quantum numbers at the ends of the flux tubes were assumed to sum up to zero. This means that the fusion of the flux tubes ending to the interior and exterior cell membrane to single one creates a flux tube state not localized inside cell and that the interior of cell carries net quantum numbers. The attractive interpretation is that this process represents the generation of quale of single nucleotide.
 - (b) The formation of the flux tube connection between lipid layers would involve the transformation of both quark-antiquark pairs to an intermediate state. There would be no kinematic constraints on the process nor to the mass scales of quarks. A possible mechanism for the separation of the two quark-antiquark pairs associated with the lipids from the system is double reconnection of flux tubes which leads to a situation in which the quark-antiquark pairs associated with the lipid layers are connected by short flux loops and separated to a disjoint state and there is a long wormhole flux tube connecting the nucleotides possibly belonging to different cells.
 - (c) The state of two quark pairs need not have vanishing quantum numbers and one possibility is that the quantum numbers of this state code for qualia. If the total numbers of flux tubes are vanishing also the net quantum numbers of the resulting long flux tube connecting two different cells provide equivalent coding. A stronger condition is that this state has vanishing net quantum numbers and in this case the ends of the long flux tube would carry opposite quantum numbers. The end of flux tube at DNA nucleotide would characterize the quale.
5. Two identification of primary qualia are therefore possible.
 - (a) If the flux tubes have vanishing net quantum numbers, the primary sensory quale can be assigned to single receptor cell and the flow of the quantum numbers corresponds to the extension of the system with vanishing net quantum numbers in two-cell system.
 - (b) If the net quantum numbers of the flux tube need not vanish, the resulting two cell system carries non-vanishing quantum numbers as the pair of quark-antiquark pairs removes net quantum numbers out of the system.
6. If the net quantum numbers for the flux tubes vanish always, the specialization of the sensory receptor membrane to produce a specific quale would correspond to an assignment of specific quantum numbers at the DNA ends of the wormhole flux tubes attached to the lipid layers of the cell membrane. The simplest possibility that one can imagine is that the outer lipid layer is connected to the conjugate DNA nucleotide inside same cell nucleus. This option would however assign vanishing net quantum number increments to the cell as whole and is therefore unacceptable.

7. The formation of a temporary flux tube connection with another cell is necessary during the generation of quale and the question is what kind of cell is in question. The connection of the receptor to cells along the sensory pathway are expected to be present along the entire sensory pathway from DNA nucleotide to a nucleotide in the conjugate strand of second neuron to DNA nucleotide of the third neuron.... If Josephson photons are able to regenerate the quale in second neuron this would make it possible to replicate the quale along entire sensory pathway. The problem is that Josephson radiation has polarization orthogonal to axons and must propagate along the axon whereas the flux tube connection must be orthogonal to axon. Hence the temporary flux tube connection is most naturally between receptor cells and would mean horizontal integration of receptor cells to a larger structure. A holistic process in directions parallel and orthogonal to the sensory pathway would be in question. Of course, the flux tube could be also curved and connect the receptor to the next neuron along the sensory pathway.
8. The specialization of the neuron to sensory receptor would require in the framework of positive energy ontology that -as far as qualia assignable to the electro-weak quantum numbers are considered - all DNA nucleotides are identical by the corresponds of nucleotides with quarks and antiquarks. This cannot be the case. In zero energy ontology and for wormhole flux tubes it is however enough to assume that the net electroweak quantum numbers for the quark antiquark pairs assignable to the DNA wormhole contact are same for all nucleotides. This condition is easy to satisfy. It must be however emphasized that there is no reason to require that all nucleotides involved generate same quale and at the level of neurons sensory maps assigning different qualia to different nucleotides and lipids allowing DNA to sensorily perceive the external world are possible.

The model should be consistent with the assignment of the fundamental bio-rhythms with the CDs of electron and quarks.

1. Quark color should be free in long enough scales and cellular length scales are required at least. The QCD in question should therefore have long enough confinement length scales. The first possibility is provided by almost vacuum extremals with a long confinement scale also at the flux tubes. Large \hbar for the cell membrane space-time sheet seems to be unavoidable and suggests that color is free in much longer length scale than cell length scale.
2. Since the length of the flux tubes connecting DNA and cell membrane is roughly 1 micrometer and by a factor of order 10^7 longer than the d quark Compton length, it seems that the value of Planck constant must be of this order for the flux tubes. This however scales up the time scale of d quark CD by a factor of 10^{14} to about 10^4 years! The millisecond and 160 ms time scales are much more attractive. This forces to ask what happens to the quark-anti-quark pairs at the ends of the tubes.
3. The only possibility seems to be that the reconnection process involves a phase transition in which the closed flux tube structure containing the two quark pairs assignable to the wormhole contacts at lipid layers is formed and leaks to the page of the Big Book with pages partially labeled by the values of Planck constant. This page would correspond to the standard value of Planck constant so that the corresponding d quark CDs would have a duration of millisecond. The reconnection leading to the ordinary situation would take place after millisecond time scale. The standard physics interpretation would be as a quantum fluctuation having this duration. This sequence of quark sub-CDs could define what might be called memetic codon representation of the nerve pulse sequence.
4. One can also consider the possibility is that near vacuum extremals give rise to a copy of hadron physics for which the quarks associated with the flux tubes are light. The Gaussian Mersennes corresponding to $k = 151, 157, 163, 167$ define excellent p-adic time scales for quarks and light variants of weak gauge bosons. Quark mass 5 MeV would with $k = 120$ would be replaced with $k = 163$ (167) one would have mass 1.77 eV (.44 eV). Small scaling of both masses gives 2 eV and .5 eV which correspond to basic metabolic quanta in TGD framework. For quark mass of 2 MeV with $k = 123$ $k = 163$ (167) one would give masses .8

eV (.05 eV). The latter scale correspond to Josephson energy assignable with the membrane potential in the ordinary phase.

In this case a phase transition transforming almost vacuum extremal to ordinary one takes place. What this would mean that the vacuum extremal property would hold true below much shorter p-adic length scale. In zero energy ontology the scaling up of quark masses is in principle possible. This option looks however too artificial.

Overall view about qualia

This picture leads to the following overall view about qualia. There are two options depending on whether single quark-antiquark pair or two of them labels the qualia. In the following only the simpler option with single quark-antiquark pair is discussed.

1. All possible pairings of spin and electroweak isospin (or em charge) define 16 basic combinations if one assumes color singletness. If arbitrary color is allowed, there is a nine-fold increase of quantum numbers decomposable to color singlet and octet qualia and further into 3×15 qualia with vanishing increments of color quantum numbers and 6×16 qualia with non-vanishing increments of color quantum numbers. The qualia with vanishing increments for electroweak quantum numbers could correspond to visual colors. If electroweak quantum numbers of the quark-anti-quark pair vanish, one has 3×7 *resp.* 6×8 combinations of colorless *resp.* colored qualia.
2. There is a huge number of various combinations of these fundamental qualia if one assumes that each nucleotide defines its own quale and fundamental qualia would be analogous to constant functions and more general qualia to general functions having values in the space with $9 \times 16 - 1$ points. Only a very small fraction of all possible qualia could be realized in living matter unless the neurons in brain provide representations of body parts or of external world in terms of qualia assignable to lipid-nucleotide pairs. The passive DNA strand would be ideal in this respect.
3. The basic classification of qualia is as color qualia, electro-weak quale, and spin quale and products of these qualia. Also combinations of color qualia and electroweak and spin quale are possible and could define exotic sensory qualia perhaps not yet realized in the evolution. Synesthesia is usually explained in terms of sensory leakage between sensory pathways and this explanation makes sense also in TGD framework if there exists a feedback from the brain to the sensory organ. Synesthesia cannot however correspond to the product qualia: for “quantum synesthesia” cross association works in both directions and this distinguishes it from the ordinary synesthesia.
4. The idea about brain and genome as holograms encourages to ask whether neurons or equivalently DNA could correspond to sensory maps with individual lipids representing qualia combinations assignable to the points of the perceptive field. In this framework quantum synesthesia would correspond to the binding of qualia of single nucleotide (or lipid) of neuron cell membrane as a sensory representation of the external world. DNA is indeed a holographic representation of the body (gene expression of course restricts the representation to a part of organism). Perhaps it is this kind of representation also at the level of sensory experience so that all neurons could be little sensory copies of body parts as holographic quantum homunculi. In particular, in the associative areas of the cortex neurons would be quantum synesthetes experiencing the world in terms of composite qualia.
5. The number of flux tube connections generated by sensory input would code for the intensity of the quale. Josephson radiation would do the same at the level of communications to the magnetic body. Also the temporal pattern of the sequence of quale mental images matters. In the case of hearing this would code for the rhythmic aspects and pitch of the sound.

Guesses about detailed identification of the qualia

One can make also guesses about detailed correspondence between qualia and quantum number increments.

1. Visual colors would correspond to the increments of only color quantum numbers. Each biologically important ion would correspond to its own color increment in one-one correspondence with the three pairs of color-charged gluons and these would correspond to blue-yellow, red-green, and black white [K96]. Black-white vision would mean a restriction to the $SU(2)$ subgroup of color group. The model for the cell membrane as a nearly vacuum extremal assigns the peak frequencies corresponding to fundamental colors with biologically important ions. Josephson radiation could induce artificially the same color qualia in other neurons and this might provide a manner to communicate the qualia to the brain where they could be re-experienced at neuronal level. Some organisms are able to perceive also the polarization of light. This requires receptors sensitive to polarization. The spin of quark pair would naturally code for polarization quale.
2. Also tastes and odours define qualia with “colors”. Certainly the increments of electroweak numbers are involved but since these qualia do not have any directional flavor, spin is probably not involved. This would give $c 3 \times 4$ basic combinations are possible and can certainly explain the 5 or 6 basic tastes (counted as the number of different receptors). Whether there is a finite number of odours or not has been a subject of a continual debate and it might be that odours already correspond to a distribution of primary qualia for the receptor cell. That odours are coded by nerve pulse patterns for a group of neurons [J88] would conform with this picture.
3. Hearing seems to represent a rather colorless quale so that electroweak isospin suggests again itself. If we had a need to hear transversely polarized sound also spin would be involved. Cilia are involved also with hair cells acting as sensory receptors in the auditory system and vestibular system. In the case of hearing the receptor itself does not fire but induces a firing of the higher level neuron. The temporal pattern of qualia mental images could define the pitch of the sound whereas the intensity would correspond to the number of flux tube connections generated.

The modulation of Josephson frequencies -rather than Josephson frequencies as such- would code for the pitch and the total intensity of the Josephson radiation for the intensity of the sound and in fact any quale. Pitch represents non-local information and the qualia sub-selves should be negentropically entangled in time direction. If not, the experience corresponds to a sequence of sound pulses with no well-defined pitch and responsible for the rhythmic aspects of music. Right brain sings-left brain talks metaphor would suggest that right and left brain have different kind of specializations already at the level of sensory receptors.

4. Somato-sensory system gives rise to tactile qualia like pain, touch, temperature, proprioception (body position). There are several kinds of receptors: nociceptors, mechanoreceptors, thermoreceptors, etc... Many of these qualia have also emotional coloring and it might be that the character of entanglement involved (negentropic/entropic) defines the emotional color of the quale. If this is the case, one might consider a pure quale of touch as something analogous to hearing quale. One can argue that directionality is basic aspect of some of these qualia -say sense of touch- so that spin could be involved besides electroweak quantum numbers. The distribution of these qualia for the receptor neuron might distinguish between different tactile qualia.

Could some sensory qualia correspond to the sensory qualia of the magnetic body?

Concerning the understanding of a detailed model for how sensory qualia are generated, the basic guideline comes from the notion of magnetic body and the idea that sensory data are communicated to the magnetic body as Josephson radiation associated with the cell membrane. This leaves two options: either the primary sensory qualia are generated at the level of sensory receptor and the resulting mental images negentropically entangle with the “feeling of existence” type mental images at the magnetic body or they can be also generated at the level of the magnetic body by Josephson radiation -possibly as cyclotron transitions. The following arguments are to-be-or-not-to-be questions about whether the primary qualia must reside at the level of sensory receptors.

1. Cyclotron transitions for various cyclotron condensates of bosonic ions or Cooper pairs of fermionic ions or elementary particles are assigned with the motor actions of the magnetic

body and Josephson frequencies with the communication of the sensory data. Therefore it would not be natural to assign qualia with cyclotron transitions. On the other hand, in zero energy ontology motor action can be regarded formally as a time reversed sensory perception, which suggests that cyclotron transitions correlated with the “feeling of existence” at magnetic body entangled with the sensory mental images. They could also code for the pitch of sound as will be found but this quale is strictly speaking also a geometric quale in the 4-D framework.

2. If Josephson radiation induces cyclotron transitions, the energy of Josephson radiation must correspond to that of cyclotron transition. This means very strong additional constraint not easy to satisfy except during nerve pulse when frequencies varying from about 10^{14} Hz down to kHz range are emitted the system remains Josephson contact. Cyclotron frequencies are also rather low in general, which requires that the value of \hbar must be large in order to have cyclotron energy above the thermal threshold. This would however conform with the very beautiful dual interpretation of Josephson photons in terms of bio-photons and EEG. One expects that only high level qualia can correspond to a very large values of \hbar needed.

For the sake of completeness it should be noticed that one might do without large values of \hbar if the carrier wave with frequency defined by the metabolic energy quantum assignable to the kicking and that the small modulation frequency corresponds to the cyclotron frequency. This would require that Josephson frequency corresponds to the frequency defined by the metabolic quantum. This is not consistent with the fact that very primitive organisms possess sensory systems.

3. If all primary qualia are assigned to the magnetic body, Josephson radiation must include also gluons and light counterparts of weak bosons are involved besides photons. This is quite a strong additional assumption and it will be found that the identification of sensory qualia in terms of quantum numbers of quark pair restricts them to the cell membrane. The coding of qualia by Josephson frequencies is however possible and makes it possible to regenerate them in nervous system. The successful model explaining the peak frequencies of photoreceptors in terms of ionic cyclotron frequencies supports this view and provides a realization for an old idea about spectroscopy of consciousness which I had already been ready to give up.

4.6.3 Capacitor model for sensory receptor

The assumption that sensory qualia are realized at the level of sensory receptors, when combined with the requirement that the average increments are non-vanishing, and perhaps even same from quantum jump to quantum jump, poses strong constraints on the model of the sensory receptor.

These constraints suggest what might be called the capacitor model of the sensory receptor.

1. There are two reservoirs of quantum charges having total charges of equal magnitude but of opposite sign. The charges are macroscopic in order to guarantee robustness. These reservoirs are analogous to capacitor plates, and only the second one corresponds to the sensory experienced quale unless both the quale and its conjugate are experienced simultaneously. Capacitors plates can carry several charges.
2. When the sensory quale is generated, there is a flow of charge quanta between the quantum capacitor plates. The charge quanta are more or less constant. This requirement could be relaxed to the condition that only the average increment is constant.

Cell membrane, or rather the pair formed by cell interior and exterior, and synaptic junction are excellent candidates for quantum capacitors.

1. During nerve pulse various ions flow between cell interior and exterior, which suggests that sub-neuronal sensory qualia are generated in a time scale of a millisecond. Also membrane oscillations might give rise to some kind of sensory qualia. In particular, super-conducting Cooper pairs and bosonic ions enter or leave the Bose-Einstein condensates at the magnetic flux tubes and this should give rise to a chemical experience defined by the quantum numbers of the carrier particle. Not only the increment of electric charge but increments of magnetic

quantum numbers characterize the qualia in question. Various information molecules transferred through the cell membrane could also give rise to sensory qualia.

2. In the synaptic contact the vesicles containing neurotransmitter are transmitted, and the net quantum numbers for the vesicles should determine the neuronal chemical qualia associated with the process.

This model does not apply to all qualia. Qualia can be also associated with the quantum phase transitions at magnetic flux quanta. A typical example is a coherently occurring cyclotron transition for a macroscopic phase of Cooper pairs. It would seem that quantum phase transitions at the magnetic flux quanta and particle flows between the quantum electrodes associated with electret type structures could define two basic types of qualia. Note that electret structures are dual to magnetic flux quanta as solutions of field equations. Vision and hearing would be basic examples of these two types of qualia.

4.6.4 Capacitor Model For Color Vision

Capacitor model allows to attack the problem of how color qualia are generated physically.

1. Color sensation results from a spatial gradient of illumination at a given wavelength transformed first to a temporal gradient: presumably by a saccadic motion. This explains color constancy naturally. The temporal gradient of illumination in turn induces a quantum jump sequence for which average increments of color isospin and hypercharge per quantum jump are non-vanishing and characterizes the color in question.
2. What is needed are two color capacitor plates with opposite color charges. Since color confinement implies the vanishing total color charges below certain length scale, the notion of color capacitor is very natural. The fact that a region of a given visual color has at its boundaries a narrow stripe with the complementary color could relate closely to color confinement. Also the after images with varying colors could relate to the back-flow of the color charges establishing the equilibrium situation between the plates of color capacitor. The color black experienced when eyes are closed could be interpreted as being due to a background flow occurring even in the absence of the visual stimulus (this sensation disappears and visual consciousness is lost if saccadic motions is not allowed to occur).
3. The temporal gradient of illumination induces a flow of color charges between the plates of the color capacitor. The coding of photon frequencies to colors results if the quanta transferred between the plates are colored particles with an isospin-hypercharge ratio characterizing the visual receptor in question. The simplest possibility is that color octet particles are in question so that three primary colors and their conjugates define the basic colors. A Bose-Einstein condensate of colored bosons is the most elegant manner to realize the capacitor. This mechanism requires only that the receptor is frequency sensitive, and that the quantum numbers of the colored particles associated with the capacitor plates depend on the receptor. Depending on the direction of the color charge flow a given receptor contributes color or its conjugate color to the experience, which is average over some set of receptors and thus a mixed color.
4. 3+3 primary colors (black and white are counted as conjugate colors) correspond naturally to the charged "gluons" in the octet representation. For higher color representations a more refined color palette results. For white-black vision the increment of the color hypercharge would be vanishing on the average. It could be also vanishing for the quanta involved (charged "gluons" belonging to $SU(2)$ triplet of gluons). If the classical color gauge field associated with the plates of the color capacitor reduces to $SU(2)$ one could indeed expect that black-white vision results.

The role of classical color gauge fields

The classical color gauge fields associated with the receptor plates could favor BE condensate with particular color quantum numbers. Classical color gauge fields in general give rise to vacuum

color currents, and these could generate coherent states of some gluon like particles giving in turn rise to BE condensates. Since classical color fields are proportional to the induced Kähler field, one expects that strong color gauge fields are associated to solutions which are far from vacuum extremals. Other sensory receptors might differ from visual receptors in that they correspond to almost vacuum space-time sheets with very weak classical color gauge fields. A weaker condition is that the classical color gauge fields are so random that only weak coherent state and BE condensate results. MEs are excellent candidates for the carriers of colored BE condensates since their CP_2 projections are 2-dimensional and the classical color gauge field is Abelian and thus corresponds to a fixed $U(1)$ sub-group.

The model leaves a lot of room for the identification of the colored particles. The color could be in color rotational degrees of freedom of the space-time sheets, it could be gluonic color for a QCD realized in cellular length scale, or super-conformal color associated with what might be called WCW photons.

Rigid body color?

The identification of the color as a degree of freedom analogous to rigid body rotational degrees of freedom is rather attractive because of its simplicity.

1. Every space-time sheet has color-rotational rigid body degrees of freedom. Since the space-time sheet is topologically condensed at a larger space-time sheet and connected by join along boundaries bonds to other space-time sheets, these degrees of freedom are partially frozen. This means breaking of color symmetry to a subgroup of color group. $U(2)$, $U(1) \times U(1)$, and $U(1)$ are the options besides complete breaking of color symmetry. This could explain why color capacitor mechanism is not involved with all cell membranes but requires special receptors.
2. The gluing operation for two space-time sheets occurs along 3-dimensional surface for both wormhole contacts and join along boundaries bonds. The requirement that gluing is possible implies that this portion of surface is a fixed point with respect to the subgroup of color group, which remains unbroken. If the region in question corresponds to a single point of CP_2 , the isotropy group is maximal and equal to $U(2)$. This means that quantum states correspond to a rigid body motion in $U(2)$. For $U(1) \times U(1)$ the states are also characterized by isospin and hypercharge. For $U(1)$ only isospin labels the states and this would correspond to black-white vision.
3. The simplest states correspond to the restriction of color representations in $SU(3)$ realized as matrix elements of color representations to $U(2)$. The restriction means that certain states drop off. To get some grasp on the situation, consider a simple example first. In the case of $SO(3)$ CP_2 is replaced by the sphere S^2 and the restriction to the group $U(1)$ drops away all matrix elements which vanish at the equator. For $J = 1$ triplet only the states having spin $J_z = \pm 1$ remain. Probably also in the case of $SU(3)$ only charged gluons survive in the octet representation restricted to $U(2)$. Since also color neutral states must be possible, the restrictions of higher representations must contain also color neutral states.
4. The freezing of color degrees of freedom means that the remaining degrees of freedom for the space-time sheet are zero mode like degrees of freedom. These degrees of freedom define what is known as a flag manifold. For $U(2)$ these degrees of freedom correspond to $CP_2 = SU(3)/U(2)$, for $U(1) \times U(1)$ the flag manifold is six-dimensional $SU(3)/U(1) \times U(1)$. Flag manifold qualia would correspond to sequences of constant changes for flag manifold coordinates. In the simplest case, sequences of steps along one parameter subgroup of $SU(3)$. The connection between the dance of the honeybee and color group made by Barbara Shipman supports the view that flag manifold coordinates define fundamental geometric qualia and are responsible, not only for the geometric aspects of vision, but of also other sensory modalities.

Gluons of scaled down versions of QCD and dark matter hierarchy

It became years ago clear that TGD allows a hierarchy of QCDs. The assumption that these QCDs are not asymptotically free allowed to circumvent the experimental bounds on the number of elementary particles. Given QCD would exist only in a certain range of p-adic length scales and thus in a certain range of energy and momentum transfers.

After the discovery of dark matter hierarchy with levels labelled by the values of Planck constant [K43, K44] it became clear that TGD not only allows but predicts hierarchies of electro-weak and color physics. Particles of different physics do not have direct interactions and bosons at a higher level of dark matter transform to bosons of a lower level by de-coherence phase transitions. In particular, ordinary intermediate gauge bosons do not decay to the particles of the predicted exotic color and electro-weak physics, and asymptotic freedom can be assumed for all these QCDs.

This forces to consider the possibility that QCDs could exist even in cellular length scales, and that Bose-Einstein condensates of gluons give rise to the opposite color charges of color capacitors. The topological condensation of gluons forces the breaking of the color symmetry for all colored particles, even gluons.

WCW photons?

TGD predicts also WCW color degrees of freedom. What is remarkable is that these states do not carry any energy and momentum. Actually infinite-dimensional super-symplectic representations decomposing into representations of color group are in question. Rigid body color would represent the lowest states of these representations. MEs are especially good candidates for carrying this kind of color. If MEs with sizes below cell membrane thickness are involved with the transfer of color between the color capacitor plates, the energies of the particles involved must be in ultraviolet range by Uncertainty Principle. If the transfer occurs between cells, the length scale could be of order micrometer and thus visible wavelengths would be in question as is indeed natural. Perhaps the structures formed by cell layers are involved with our color qualia.

4.6.5 The Structure Of The Retina And Sensory Organs As Sites Of Sensory Qualia

The assumption that sensory organs are carriers of the sensory representations entangling with symbolic representations realized at the level of cortex does not mean any revolution of neuroscience, just adding something what is perhaps lacking. Neuronal/symbolic level would do its best to symbolically represent what occurs naturally at the level of qualia. Color constancy could be understood as a basic characteristic of color qualia re-realized at the neuronal level.

Center-surround opponency for the conjugate colors is the neural counterpart for the contrast phenomenon in which the boundary for a region of the perceptive field with a given color carries the conjugate color (black-white opponency associated with the luminance is only a special case of this). The contrast phenomenon at the level of visual qualia could derive from the vanishing of the net color quantum numbers for the electrodes of the retinal color capacitors.

The basic prediction is the presence of the back projection at least in the sensory modalities in which hallucinations are possible. MEs with MEs mechanism is the most natural candidate for realizing the back projection, negative/positive energy MEs would realize the back projection based on quantum/classical communications, and the capacitor model of the sensory receptor can be applied to model photoreceptors and retina. This picture integrates nicely with the various speculations about the role of the ciliary micro-tubules in vision. The obvious question is how the presence and character of the back projection reflects itself in the structure of the sensory pathways and sensory organs. Basic facts about how gastrulation and neurulation proceed during the development of the embryo, lead to testable predictions about the character of the back projection for various sensory modalities, and one can speak about “brain senses” and “skin senses” according to whether the back projection is based on quantum or classical communications.

Various micro-tubular structures as photoreceptors/transducers

There is a definite evidence supporting the idea that micro-tubuli might be involved with a primitive vision. The information below is from the lecture “Quantum Vitalism” of Stuart Hameroff during

an online course about quantum consciousness held in Arizona University 1999.

Albrecht-Buehler [I121] has shown that single fibroblast cells move toward red/infra-red light by utilizing their micro-tubule-based centrioles for directional detection and guidance; he also points out that centrioles are ideally designed photodetectors. Photoreception/phototransduction mechanisms at all stages of evolution involve the nine micro-tubule doublet or triplet structures found in centrioles, cilia, flagella and axonemes. The centriole is a pair of micro-tubule-based mega-cylinders arrayed in T shape [I146]. Albrecht-Buehler has identified centrioles as the photoreceptor/phototransducer in photosensitive eukaryotic cells.

Flagellar axonemes are the photosensitive structures in protozoa such as *Euglena gracilis*. Cilia in rod and cone retinal cells in vertebrate eyes (including humans) bridge two parts of the cells and have length distribution covering visible wavelengths. Photosensitive pigments (rhodopsin) is contained in the outer segment while cell nucleus, mitochondria and synaptic connection are contained in the cell body. Light enters the eye and traverses the cell body and cilium to reach the rhodopsin-containing outer segment.

Mari Jibu, Kunio Yasue and colleagues [J60] have proposed that super-radiance in a micro-tubule could be involved with the photo-reception.

1. The energy gain due to the thermal fluctuations of tubulins is assumed to increase the number of water molecules in the first excited rotational energy state.
2. A collective mode of the system of water molecules in rotationally excited states is generated. A long-range coherence is achieved inside a micro-tubule by means of spontaneous symmetry breaking. The collective mode of the system of water molecules in rotationally excited states loses its energy collectively, and creates coherent photons in the quantized electromagnetic field inside a micro-tubule.
3. Water molecules, having lost their first excited rotational energies by super-radiance, start again to gain energy from the thermal fluctuation of tubulins, and the system of water molecules ends up to the initial state. Jibu and collaborators have predicted that cellular vision depends on a quantum state of ordered water in micro-tubular inner cores. The authors postulate a nonlinear quantum optical effect termed “super-radiance” conveying evanescent photons by a process of “self-induced transparency” (the optical analogue of super-conductivity) involving formation of BE condensate of photons.

Interestingly, the energy scale of the rotational excitations of water is that of microwave photons, and microwave MEs play a key role in bio-control in the TGD based model of living matter. Perhaps the mechanism proposed by Jibu and collaborators could have a variant realized in terms of TGD based physics and involving microwave-, visible-, and very low frequency MEs. In particular, the collective excitation of the water inside micro-tubule could be generated by coherent radiation of microwave photons accompanying microwave MEs rather than thermally. On basis of the second law one could indeed argue that thermal excitations cannot lead to the generation of macroscopic quantum coherent states.

In simple multicellular organisms, eyes and visual systems began with groups of differentiated light-sensitive ciliated cells which formed primitive “eye cups” (up to 100 photoreceptor cells) in many phyla including flatworms, annelid worms, molluscs, crustacea, echinoderms and chordates (our original evolutionary branch). The retinas in human eyes include over 4×10^8 rod and cone photoreceptors each comprised of an inner and outer segment connected by a ciliated stalk. Since each cilium is comprised of about 3×10^5 tubulins, our retinas contain about 3×10^{13} tubulins per eye. Retinal rods, cones and glia are interconnected by gap junctions [J91] and this could be crucial for the generation of the macro-temporal quantum coherence, which quite generally relies on the generation of flux tubes connecting the boundaries of the space-time sheets forming the bound state in question.

It is usually assumed that the cilium is a purely structural element, but the centriole/cilium/flagella micro-tubular structure, which Albrecht-Buehler has analyzed as an ideal directional photoreceptor, may detect or guide photons in eye spots of single cells, primitive eye cups in early multicellular organisms, and rods and cones in our retinas. The proposal that retinal macro-temporal quantum coherence leading to a new qualitative level of consciousness with much longer de-coherence time could have emerged in sheets of gap junction-connected ciliated cells in eye cups of early Cambrian worms, generalizes the vision of Hameroff and Penrose to TGD context.

The identification of the color capacitor structure

The first segment of the photoreceptor consists of the cell soma and a part containing mitochondria. This segment is connected by ciliated stalk to a layered structure containing the photosensitive pigments. The length distribution of the ciliary micro-tubuli covers visible wavelengths.

The closing of eyes generates so called dark current [J58] flowing along the receptor and inducing the hyper-polarization of the receptor membrane. Since visual consciousness is not lost, the natural TGD inspired conclusion is that dark current is the neural correlate for the quale black as a background color quale which in turn results by the color capacitor mechanism.

The fact that vertebrate retina differs by inversion from the retina of invertebrates [?] inspires the question whether the micro-tubular vision of invertebrates about external world might have been inverted to produce “inner vision” providing back projection in the case of the vertebrates. If so vertebrate cilia would receive the “inner light” or generate it itself with brain remotely controlling the process. Mitochondria in turn could provide the needed metabolic energy but could also act as amplifiers of the incoming light.

The photosensitive layers consist of endoplasmic membranes so that the realization of the capacitor mechanism would be the same as for the ordinary axonal membrane (nerve pulse inducing flows of ions giving rise to the neuronal chemical qualia). The membrane would be at criticality as regards to the occurrence of the spontaneous color discharge and incoming photon would cause the breakdown. Since the color discharge can be assumed to flow from the side determined by the direction of the membrane electric field, each layer generates same visual qualia although the direction of the color discharge varies. Layered structure would increase the sensitivity of the retina and facilitate the recharging of the capacitors since discharge would make intermediate regions charged and thus unstable.

It would not be surprising if also the endoplasmic membranes filling the cell interior might serve the purpose of acting as quantum capacitors providing neuron with sensory receptors of various kinds. Also neuronal vision is quite possible: the difference from our vision would be that our vision involves integration of a very large number of neuronal experiences (more than 1 billion receptors) by quantum entanglement to form our vision. The gap junctions between visual receptors would make possible macro-temporal quantum coherence and the fusion of receptor level visual mental images to our visual mental images.

Back projection mechanism

The basic mechanism responsible for the back projection would involve curved low frequency MEs. Low frequency MEs could be regarded as topological light rays inside effective wave cavities defined by the magnetic flux tubes parallel to the axons, and leading from the cortex to lateral geniculate nucleus to ganglions to the retina. These magnetic flux tubes would form a part of the magnetic body associated with the retina and have quite large a size. Inside low frequency MEs high frequency MEs would propagate as effectively massless particles. In the case of vision high frequency MEs would have lengths in the wavelength range covering that of the visible light.

1. The inverted structure of retina and back projection hypothesis

Photo receptors consist of rods and cones. Only rods are active at low luminance level (black-white vision). Cones are active at high luminance levels and sensitive to the wavelength of the light. Receptor cells are coupled via bipolar cells to ganglions which in turn feed the sensory input along the inner surface of the retina to the blind spot, and from the blind spot to the lateral geniculate nucleus (LGN) of the thalamus. Below (above) bipolar cells are horizontal (amacrine) cells responsible for the lateral couplings between receptor bipolar synapses.

Back projection hypothesis could allow to understand why the incoming light meets first ganglions and wanders through amacrine, bipolar, and horizontal cells to receptors. The inverted structure is indeed required by the back projection: the inner light (coming along, say curved MEs parallel to magnetic flux tubes parallel to micro-tubuli to ganglions or even remotely generated in the ciliated stalk), must superpose with the incoming light. If the structure would be what a naïve engineering argument would suggest, the inner light should meet the receptors from an opposite side than the light from the external world, and thus from a wrong side.

2. Back projection and retinal magnetic body

It is interesting to relate back projection to the retinal magnetic body. The following two arguments lead to the same estimate for the size of the retinal magnetic body.

1. The value of the ratio f_h/f_l of high and low frequencies appearing in the scaling law of [I23] [K58] determines f_l . For the value $f_h/f_l \simeq 2 \times 10^{11}$ identifiable as the ratio of the ionic zero point kinetic energy at atomic space-time sheets and ionic cyclotron energy E_c in the Earth's magnetic field, this would predict that f_l is about $f_l \sim 3$ kHz so that retinal magnetic body would have size of order 100 km.
2. The scaling law relating the sizes L_{CNS} of brain structures to the sizes L_{magn} of the corresponding magnetic bodies would give in the case of eye $L_{magn} = (c/v)L_{CNS}$, where v is the conduction velocity of nerve pulses or some other relevant velocity parameter. For $v = 10$ m/s and the size of retina about $L_{CNS} \sim 1/3$ cm, this would give $L_{magn} \sim 300$ kilometers so that the estimates are of same order of magnitude.

The ratio c/v could be interpreted as the ratio of the ionic zero point kinetic energy at the cell membrane space-time sheet and of the ionic cyclotron energy E_c . The thickness of the ionospheric cavity is approximately $d = 100$ km. Could this mean that the size of the retinal magnetic body is determined by the thickness of this cavity believed to also give rise to Schumann resonances? If so, then low frequency retinal MEs could be seen as correlates for a radiation moving between the Earth's surface and ionospheric lower boundary forth and back, somewhat like between two mirrors. For $d = 100$ km the period for a single forth-back reflection would be $\tau = .67$ ms, which is near to the duration .78 ms for a single bit of the memetic codon. For $d = 118$ km the duration of the memetic bit would result. Of course, retinal magnetic flux tubes could also be loops returning from the surface of the ionosphere which would make τ longer. If this identification is correct, the temporal variations of various perceptive time scales, say the time resolution of visual perception, determined by the duration of memetic bit, could correlate directly with those of d . In particular, during night time, when ionosphere tends to fall to lower heights, the time scales would become shorter making reaction times shorter.

3. Negative or positive energy MEs or both?

There are reasons to believe that negative energy MEs act as quantum entanglers whereas positive energy MEs are dissipative structures in the sense that the effective phase velocity of the classical fields associated with them is much slower than light velocity. The quantum mechanism leading to the lowering of the effective phase velocity would be basically the sticking of the ME along its boundaries to say cell membrane space-time sheet and to the magnetic flux tube of the Earth's magnetic field.

According to the general model of the motor action as a geometric time reversal of the sensory perception, motor action involves always the generation of low frequency negative energy MEs. Their presence explains the findings of Libet related to the active aspects of consciousness and implies that motor action involves precognitive aspect. The interpretation would be that some higher level structure of CNS or even magnetic body draws negative energy from the motor organs with the mediation of the negative energy MEs. In the case of sensory perception low frequency negative energy MEs would act as bridges allowing the sharing of the mental images between brain and sensory organ.

To sum up, one has two basic options: classical and quantum:

1. Positive energy MEs are involved with the back projection. In this case back-projection would be based on classical communications.
2. Negative energy MEs are responsible for the back projection which might be regarded as a generalized motor action. The phase conjugate of the laser wave would be the standard physics analog. If so then buy now-let other pay mechanism making possible remote metabolism could be involved with the back-projection. This mechanism is the basic mechanism of the metabolism in TGD framework [K62] and implies extreme flexibility.

There are reasons to believe that both options are realized, and one can classify sensory modalities according to whether the back projection is realized by classical or quantum communications. One can also relate these two options to what happens to the embryo during the gastrulation and neurulation.

4. *Where the control of back projection mechanism is?*

One should also understand where the MEs at visible frequencies are generated.

1. Fractality suggests that the back projections are generated at several levels: ganglions, LGN and various sensory areas. For option 2) the generation of the inner light could mean generation of the quantum entangling negative energy low frequency ME carrying inside it negative energy visible frequency MEs to the appropriate part of the brain. The process could be interpreted as sucking of negative energy from retina.
2. Back projection could be partially responsible for the appearance of the conjugate color at the boundary of a region of given color to improve contrast. Neuronal level would mimic this qualia level phenomenon at levels of the hierarchy. Whether back-projection from ganglia could relate the on-off structure of the receptive fields even at ganglion level, is an open question. The appearance of the conjugate color at the boundaries of a region of the visual field of a given color could relate to the vanishing of the net color charge for the “positive” electrodes of the system of parallel color capacitors formed by the photoreceptors coupled by gap junctions to form single macroscopic color neutral system.
3. The chromo-oxidase (CO) blobs associated with the visual areas V1 and V2 [J83] are a signature of high metabolic activity. For option 2) this would mean that the mitochondria in the neurons of CO blobs suck negative energy photons from some part of the retina, perhaps from the micro-tubuli in the ciliated stalk. The interpretation would be that retina shares the mental image representing the desire of some higher level structure to modify the sensory image and acts accordingly. For option 1) CO blobs would generate positive energy visual MEs propagating to the retina along low frequency MEs: this communication would be classical and limited by the effective phase velocity of the positive energy MEs, presumably of order 10 m/s.

5. *Which cellular structures are involved with the generation of the inner light?*

The basic question is which cellular structures are involved with the, possibly non-local, generation of the inner light and which are the mechanisms involved. One can imagine several options. Option 1) is most plausible in the case of vision and olfaction whereas option 2) might be realized when the back projection occurs via classical communications.

1. Mitochondria could act as suckers of the negative energy from the retina. Cytochrome oxidase (CO) [J83] is involved with the liberation of the metabolic energy and is associated with mitochondria which are everywhere. The large amount of CO in CO blobs suggest that they are metabolically very active. This could be due to the sucking of negative energy photons responsible for the remote metabolism at retina. Note that this mechanism would be essentially lossless and could be said to involve a temporal change of the arrow of the geometric time at the level of MEs. In fact, it is known that metabolism is almost lossless.
2. Mitochondrial autofluorescence could generate the inner light actively [I122] rather than as a mere by-product of metabolism: in this case however positive energy photons would be generated at CO blobs. The study of fluorescent life forms, say fireflies and life forms able to change their skin color might provide understanding about the feasibility of back projection using this mechanism (applying for option 1)).
3. Also cell nucleus must be considered as a candidate for the source of the inner light. Cell nucleus is believed to produce bio-photons and they cover just the right frequency range. The TGD based model for bio-photons leads to the conclusion that pairs of positive and negative energy MEs are involved with the standard mechanism of the bio-photon emission. Nucleus could participate in the processing of the neuronal sensory input actively if the intronic portion of the genome expresses itself using MEs obeying swift dynamics. In the case of positive energy MEs communications would be classical and memetic code could be involved. The nuclear inner light is naturally involved with the communications between cell nucleus and membrane and cellular vision. If the cell nucleus is the brain of the cell,

one must keep mind open for the possibility that cell nuclei inside CO blobs control the generation of inner light by drawing negative energy photons from receptors. The absorption of compensating positive energy photons from the mitochondria would be however necessary and make the mechanism too complicated. A somewhat more natural mechanism would be based on sending of negative energy bio-photons to mitochondria and positive energy bio-photons to the retinal receptors along low frequency MEs. Certainly the simplest option is that mitochondria control back-projection by sucking negative energy from retina.

6. Do the cilia/mitochondria in photoreceptors serve as pre-amplifiers?

Cilia might act as pre-amplifiers for the light coming from the external world, at least in the case that the illumination is very weak. If the inner light comes from brain as positive energy photons (option 1)), it is expected to have extremely weak intensity and pre-amplification mechanism could be at work also now. For option 2) the pre-amplification mechanism would be replaced by the sharing of the mental image representing the desired modification of the visual mental image and realized by buy now-pay later mechanism.

One can consider at least two different options for the pre-amplification mechanism.

1. Cilia act as pre-amplifiers and the process is triggered by the incoming inner light by a stimulated emission mechanism for which the rate for the generation of photons is proportional to N^2 , N the number of photons already existing in the system. For option 1) this mechanism would be at work also for the inner light.
2. The article about reversible excited light induced enhanced fluorescence (briefly RELIEF [I122]) supports the view that mitochondria need not only produce fluorescence as a passive by-product of energy yield but could act as amplifiers of the incoming light [I122]. Also now buy now-pay later mechanism could be involved. RELIEF phenomenon allows to consider the possibility that the large number of mitochondria preceding cilia in the visual receptors could serve as a pre-amplifier for the incoming inner light. The precise information about the mechanism of autofluorescence in the case of fireflies and life forms able to change their skin color might provide strong constraints on the model.

Does the back projection emerge in the transition from invertebrates to vertebrates?

Three inversions characterize the transition from invertebrates to vertebrates.

1. The inversion of the retina occurs [?].
2. In vertebrates *resp.* invertebrates incoming color generates hyper-polarization *resp.* polarization of the receptor membrane [?]. Thus it would seem that the roles of white and black are changed in the vision of invertebrates: invertebrates detect the lack of light.
3. During morphogenesis the generation of neural tube giving rise to spinal cord, motor nerve, eyes and other sensory organs in head occurs [A13], [I53]. Neural tube is formed through a folding process implying that neural tube results essentially from an inside-outside inversion of the outer epithelial sheet of the skin.

The finding that neural tube and skin are related by inversion inspires the following questions.

1. Could one relate the first two inversions to the third one? The following arguments summarizing the basic facts about gastrulation and neurulation support this guess.
2. What implications the inversion could have for consciousness? Did it change the character of some sensory modalities in a decisive manner so that one see “skin senses” and “brain senses” as inversions of each other in some sense. Could it be that the “skin senses” do not involve the telepathic back projection and that the possible back projection is based on classical communications in this case? Could one understand the emergence of the vertebrates as a step in which the telepathic back projection emerged in vision and perhaps also in some other sensory modalities like olfaction, and made vertebrates dreamers and artists building visual representations as caricatures? Could it be that under appropriate circumstances

tactile senses could provide telepathic information from the external world making possible a telepathic remote sensing which in general need however not provide information directly conscious-to-us?

1. *Gastrulation and the differences between vertebrates and invertebrates*

Gastrulation [A13], [I53] during which the growing embryo gets gut, is said to be the most important and vulnerable period in the life cycle of a multi-cellular organism. During this period the embryo begins to express its own genome (mother's genome has taken care of development hitherto). The details of this process differ for invertebrates (sea urchin is standard example), amphibians (say frog), and higher vertebrates (birds, reptiles, mammals). In the case of vertebrates the process leads to the generation of essentially three kinds of cell populations. Endoderm develops to inner organs like stomach, intestine and lungs. Mesoderm consists of cells originally contained by the surface of the blastula and differentiates to muscles and inner organs like heart. Ectoderm is the outermost cell layer of the embryo consisting two parts which differentiate later to the nervous system and skin.

For invertebrates gastrulation occurs through a process known as invagination, which is essentially the in-pocketing of the epithelial sheet. The pocket like structure elongates to gut tube like structure consisting mainly of endoderm. The nervous system develops from the mesoderm.

Gastrulation occurs differently for amphibians and higher vertebrates. In the case of amphibians gastrulation involves so called involution which means that the mesoderm part of the epithelial sheet rolls below the epiderm to form a double-layered structure (the folding of a rug gives idea of what happens). This process occurs for both halves of the embryo and give. In the case of birds, reptiles, and mammals the gastrulation starts from a situation to which gastrulation leads in the case of amphibians. This in the sense that the outer surface of the blastula is a double layered structure consisting of epiblast and hypoblast below it already in the beginning of the gastrulation. The ingression (detachment) of the cells from the the epiblast *resp.* hypoblast sheet to the interior of the blastula gives rise to mesoderm (muscles, heart, ..) *resp.* endoderm (stomach, intestine, lungs, ...). The remaining epiblast will later transform to skin and nervous system.

2. *Neurulation and the difference between "skin senses" and "brain senses"*

Before neurulation the outer surface of the vertebrate embryo consists of two parts: the future skin and neural plate forming the future nervous system [A13] , [I53]. During neurulation the ectoderm in neural plate invaginates to form neural tube and neural crest between the neural tube and the ectoderm surface forming the future skin. Neural crest is formed by the ingression of cells from the skin and gives rise to sensory and autonomic nerves, Schwann cells, pigment cells, ... Neural tube in turn gives rise to brain, spinal cord, motor nerves, eyes, ...

The surface of the neural tube is essentially the outer layer of the skin, which has suffered inside-outside inversion. The inversion might mean that the external world is replaced effectively by internal world as far as possible sensory experiencing relying on micro-tubule based sensory organs is considered. This suggests that all "brain" senses such as vision and olfaction involve a telepathy based back projection (sharing of mental images) in an essential manner. "Skin senses", in particular hearing, would in turn involve non-telepathic back projection based on classical communications. Invertebrate eye is formed from the surface cell layer which has not suffered inversion: this could explain why vertebrate and invertebrate eyes differ by inversion. Invertebrates are "almost-predicted" to have back projection based on the classical signalling, in particular in the case of vision: this prediction is testable.

If hearing is "skin sense", as suggested by the fact that we "hear" low frequencies by skin (besides my fragmentary information on the development of the embryo), one must conclude that the back projection to ears must be classical. This conforms with the fact that geometro-temporal patterns of sound waves are the key element of audition. Oto-acoustic sounds audible even by outsiders are indeed a well-known phenomenon and also tinnitus should be caused by back projection involving classical signalling, perhaps by MEs inducing oscillations of nuclei and thus sounds in the inner ear. The hallucinations in "skin senses" and "brain senses" should have a different character. This might explain why dreams are usually either visual or based on internal speech whereas the dreams accompanied by auditory hallucinations are rare and those involving tactile sensations even rarer.

Telepathic “skin senses” (with hearing included) are predicted to be possible and should involve a sharing of remote mental images. The shared mental image need not be directly conscious-to-us. Interestingly, galvanic skin response is a well-known physiological correlate of parapsychological effects and skin seems to play an important role quite generally (e.g. healing by touch and the time varying magnetic fields emitted by the hands of some persons with psychokinetic abilities). Blind people can develop tactile vision and also tactile hearing is possible: an interesting question is whether these senses involve quantum entanglement with the object of the perceptive field. The “sense of presence” might also be seen as a remote “skin sense”. That car driver experiences the road through the heels of the moving car as if the vehicle were a part of his body, might be understood in terms of the entanglement associated with touch. Furthermore, it is far from trivial how we know that the sounds from the external world really enter from the external world: perhaps quantum entanglement with the sources of the sound waves is part of the explanation.

The notion of bicamerality introduced by Jaynes [J85] inspires the hypothesis that bicamerals and also schizophrenics can receive conscious information from collective levels of consciousness as auditory and visual hallucinations (see the last part of the book). The direct sharing of sensory mental images or of symbolic mental images back projected to sensory mental images would be in question. In the case of auditory hallucinations this process should involve classical back projection unless a genuine telepathy is in question. This prediction could be perhaps tested by studying the physiological correlates of hallucinogen induced experiences.

3. Back projection hypothesis and olfaction

Back projection hypothesis could allow to understand also some strange findings about insect olfaction.

1. As Callahan has demonstrated, insects experience odorant molecules through the infrared light that they generate, rather than chemically [?].
2. Olfactory and visual receptors resemble strongly each other. The fact that olfactory bulb can be seen as part of brain, suggests that the inversion of the receptors occurred also for infrared sensitive micro-tubular receptors, that the back projection is “telepathic” also in the case of the odor perception, and that for “brain senses” the sensory input is always transformed to photons at some wavelength range before it enters to the quantum capacitor and is transformed to qualia.

The infrared light responsible for the “inner odors” could be generated by the same mechanism as the “inner light” the case of vision and would probably involve micro-tubular structures. The micro-tubuli involved with odor receptors should have lengths in the range 5-100 micrometers. Albrecht-Buehler, who has done a lot of experimental work in cellular infrared vision, has demonstrated that infrared signals affect the behavior of cells and that the infrared detector is in the centrosome [I120].

How to test the general model?

The basic assumption of the model are following.

1. Sensory organs are the seats of the sensory qualia and basic sensory representations are realized at the magnetic bodies associated with the sensory organs.
2. Back projection is based on quantum *resp.* classical communications for “brain senses” *resp.* “skin senses”.

There are huge quantities of information about sensory perception so that one can invent tests for these assumptions by just going to Mednet and by loading abstracts.

1. Phantom sensations, back projection, and the notion of magnetic body

Tactile hallucinations provide interesting tests and challenges for the notion of magnetic body and for the assumption about sensory organs as seats of sensory qualia.

1. It is known that a tactile stimulation of the existing leg can evoke a dual phantom sensation in a symmetric position, that visual input affects the spontaneous but not the evoked phantom

sensation, and that sensory-motor input affects the spontaneous phantom leg sensation [J59]. The role of the visual input suggests that the evoked phantom leg sensation involves an erratic localization of the tactile sensation at the level of the sensory map of the geometric now and thus involves cortical information processing. The loss of the leg need not lead to the loss of the magnetic body associated with the leg. The tactile back projection could generate tactile mental image in the stump of the leg, which would be entangled with a point of the magnetic body of the amputated leg at the same position as the tactile mental image associated with the existing leg.

Phantom leg could be also understood if one accepts the vision about 4-D brain and TGD view about memory. Pain in phantom leg would be sensory memory of pain in the leg, which still existed. The memory feats of idiot savants and people with left brain damage would be most naturally also due to sensory (visual or auditory) memories. Also ordinary people can have sensory memories when neurons in temporal lobes are stimulated electrically.

2. The sharing of mental images in principle makes possible to have sensory experiences without sensory input to cortex, a genuine quantum telepathy in the scale of the human body. Anton's syndrome could be seen as an example of this. Also various bodily sensations experienced when the afferents to the brain are anesthetized could be seen as sensory telepathy. Typically sensations of swelling, elongation, and shortening as well as of cold, warm, and prickling are involved ("numbness" of hand is familiar to anyone) [J68]. The latter sensations could be interpreted as an evidence for the sharing of sensory mental images. The experiences about swelling, elongation and shortening would result from the erratic estimation of the geometric parameters of the body part in the absence of the sensory input to the cortex implying in turn the distortion of the image of the body part at the magnetic body.

2. Basic tests for back projection mechanism

Dreams and hallucinations should not involve "skin senses" except in the case that classical back projection is activated. Auditory/tactile hallucinations should involve classical communications from brain to ears/skin unless geometric memories or remote sharing of mental images are involved. Hypnotically induced hallucinations combined with the physiological monitoring of primary sensory organs and sensory pathways allow to test whether the predicted differences between skin and brain senses are indeed there.

The presence of the back projection could be tested by using hypnotic suggestion to experience particular qualia. One can test whether it is possible at all experience hypnotically induced tactile qualia and does this experience involve classical signalling from brain. One could test whether something occur in color receptors of a person with closed eyes or in a dark room under hypnotic suggestion. One could investigate whether the activity of CO blobs or say P cells in LGN correlates directly with the activity at the retinal level during hallucinations. One could check whether the back projection for invertebrates involves always classical signalling.

3. Hypnosis and back projection

The findings about hypnosis and color vision [J63] suggest more detailed tests for the back projection hypothesis.

1. The study in question was designed to determine whether hypnosis can modulate color perception. Such evidence would provide insight into the nature of hypnosis and its underlying mechanisms.
2. Eight highly hypnotizable subjects were asked to see a color pattern in color, a similar gray-scale pattern in color, the color pattern as gray scale, and the gray-scale pattern as gray scale during positron emission tomography scanning by means of CO_2 . The classic color area in the fusiform or lingual region of the brain was first identified by analyzing the results when subjects were asked to perceive color as color versus when they were asked to perceive gray scale as gray scale.
3. When subjects were hypnotized, color areas of the left and right hemispheres were activated when they were asked to perceive color, whether they were actually shown the color or the

gray-scale stimulus. These brain regions had decreased activation when subjects were told to see gray scale, whether they were actually shown the color or gray-scale stimuli. These results were obtained only during hypnosis in the left hemisphere, whereas blood flow changes reflected instructions to perceive color versus gray scale in the right hemisphere, whether or not subjects had been hypnotized.

4. The conclusions were that among highly hypnotizable subjects the observed changes in subjective experience achieved during hypnosis were reflected by changes in brain function similar to those that occur in visual perception. These findings support the claim that hypnosis is a psychological state with distinct neural correlates and is not just the result of adopting a role.

The findings of [J63] inspire following comments.

1. The occurrence of hypnotically induced changes in brain function similar to those occurring in visual perception supports the view that sensory organs are the seats of the primary sensory experience. If eyes are the seats of color qualia, hypnosis should induce back projection as is also obvious from the fact that hypnosis induces hallucinatory experiences. The occurrence of the back projection could be tested by using hypnosis in the absence of external light stimulus by testing what happens whether color receptors are active when person is hypnotized to see color.
2. That the left hemisphere is less gullible in ordinary wake-up consciousness supports the role of right hemisphere as the new-ageish entangler and of the left hemisphere as the skeptic loner. Parts of right brain would become more easier extensions for the brains of suggestive persons even without hypnosis. Right brain hemisphere could also be the sensory artist, and thus the dominating generator of the inner light associated with the back projection. Right brain hemisphere could also generate the inner “voices” of auditory hallucinations as Jaynes proposes [J85] or be entanglement with some higher level of self hierarchy using right brain hemisphere to generate the hallucinations.

4. Models for sensory organs and back projection

The insights provided by the study of the structure of the retina encourage to think that a detailed data about various sensory receptors and their development during embryo period could provide a lot of insights about the mechanisms generating sensory qualia and about the mechanisms of the back projection and lead to testable predictions. This would however require a lot of professional knowhow. Also the possible role of bio-photons in back projection might be amenable to study.

4.6.6 Some Examples About Deficits Of Color Vision As A Test Of The Model For Cognitive Representations

The article “Quining the Qualia” by Daniel Dennett gives [J37] a good view about the difficulties encountered as one tries to understand qualia as a philosopher. Dennett’s reaction to the problems is to give up the notion of qualia altogether. To me this is like denying the causal role of consciousness just because we do not have mathematical and conceptual tools to describe it. This is however not the main point now. Dennett lists some fascinating empirical findings related to deficits in color vision, which serve as excellent tests for any theory of qualia.

It is instructive to consider these examples in the framework provided by the model of cognitive representations just discussed. For this purposes let us list the basic general assumptions of the model in the case of color vision.

1. The paradoxical fact that receptor cells hyper-polarize rather than depolarize as they receive light is consistent with the requirement that incoming light must increase the color voltages between cone system and its magnetic body in order to generate color discharge. Rods would differ from cones in that the full color algebra $SU(3)$ to its sub-algebra $SU(2)$ so that only the increments of color isospin I_3 would be perceived and would give rise to black and white as

primary qualia. Thus only charged $SU(2)$ gluons are exchanged between the magnetic body associated with the rod system.

In the case of cones the most natural assumption is that all 3+3 colors (black and white are counted as colors) are perceived and correspond to increments of color isospin and two generators carrying hyper charge. Single cone could be specialized to produce up the increment of color quantum numbers corresponding to a particular primary color. The increment of color quantum numbers should always have the same sign in the ideal situation (only quale which is red or green, blue or yellow, black or white is produced if the highest weight or lowest weight states of the representation of color algebra (or color Kac-Moody algebra) define the ground state of the system.

2. Cortex is assumed to participate actively to the coloring of the sensory map by using back projections to retina and the experienced color map is an outcome of a complex information processing.
3. The magnetic bodies of retina would contain regions where colors are cognitively represented as an analog of color circle so that the over all color sensation generates cognitive and emotional representations as a “somatosensory” experience at the magnetic body realized as cyclotron phase transition patterns. Pure colors would correspond to patterns localized at single point of the magnetic body whereas mixed colors would correspond to de-localized patterns.

First example

Objects to the right of the vertical meridian appeared to be of normal hue, while to the left they were perceived only in shades of gray, though without distortions of form... He was unable to recognize or name any color in any portion of the left field of either eye, including bright reds, blues, greens and yellows. As soon as any portion of the colored object crossed the vertical meridian, he was able to instantly recognize and accurately name its color.

This finding could reduce the plausibility of the hypothesis that sensory organs are seats of sensory qualia and of primary cognitive and emotional representations. The hypothesis passes the test. Retina decomposes to nasal and temporal retina. This corresponds to the decomposition of the visual field of retina to right and left hemifields [L66]. The inability to recognize and name colors in the left visual could be simply due to the fact that cones sensitive to color are not functioning properly or at all in the left temporal and right nasal retina. A more complex situation would results if parts of cortex responsible for the back projections to the left visual field want to “see the world as grey” and actively reduce the color map to the shades of grey.

Second example

The patient failed in all tasks in which he was required to match the seen color with its spoken name. Thus, the patient failed to give the names of colors and failed to choose a color in response to its name. By contrast, he succeeded on all tasks where the matching was either purely verbal or purely nonverbal. Thus, he could give verbally the names of colors corresponding to named objects and vice versa. He could match seen colors to each other and to pictures of objects and could sort colors without error.

What was remarkable that the patient was not aware of any deficit.

There is an obvious analogy with the phenomenon of absolute ear. Almost anyone can tell whether two notes have the same pitch but only people with absolute ear learn to name the heard note. In the case of color vision almost all of us have “absolute eye” in the sense that we can recognize the perceived color and name it but in the above described case this ability would be lost. The analogy is weakened by the fact that musicians not possessing absolute ear are quite well aware of their “deficit”.

Accepting the analogy, the TGD based model for absolute ear generalizes as such to the recent situation. The model of absolute ear is based on a comparison in which reference dark photon signal is sent from the temporal planum [J73] to the magnetic body assignable to the cochlea. Recognition relies on the constructive interference of the dark photon signals from cochlea and temporal planum enhancing the rate for the cyclotron phase transition. This model generalizes

to a general model for how conscious pattern recognition occurs at the level of the magnetic body and applies in the case of vision too.

1. There should exist a region of visual or associative cortex analogous to the temporal planum sending a dark photon signal to the magnetic body of retina.
2. That the patient is not aware of the syndrome suggests that the reference signal representing given name of color as actual color is sent but goes to a “wrong address” at the magnetic body and is not compared with the real signal. If the cognitive “color circle” correspond to a small portion of the magnetic body as the general model for cognitive representations suggests, the resonance could indeed occur at wrong position of the magnetic body receiving different kind of cognitive input.

Third example

One morning in November 1977, upon awakening, she noted that although she was able to see details of objects and people, colors appeared “drained out” and “not true.” She had no other complaint... her vision was good, 20/20 in each eye... The difficulty in color perception persisted, and she had to seek the advice of her husband to choose what to wear. Eight weeks later she noted that she could no longer recognize the faces of her husband and daughter... [So in] addition to achromatopsia, the patient had prosopagnosia, but her linguistic and cognitive performances were otherwise unaffected. The patient was able to tell her story cogently and to have remarkable insight about her defects.

This case could be understood as the failure of the back projection mechanisms making possible coloring of the percept and the generation of the caricature like percept allowing recognition of faces. Also the recognition of faces could rely on the resonance mechanism in which signal is sent from cortex to an appropriate magnetic body.

These examples should demonstrate that the TGD based notion of qualia combined with the general model for cognitive and emotional representations can easily explain the findings discussed in [J37].

4.6.7 Odor Perception And Quantum Coherence

In Discover magazine there is an article titled *Is Quantum Mechanics Controlling Your Thoughts?* [I148] telling among other things about the latest direct evidence of quantum effects provided by experiments related to odor perception. The article discusses the work of the biophysicist Luca Turin [J94] about odor perception as an additional support for quantum brain. Before going to the article it is good to summarize the basic ideas about sensory qualia (colors, odors, ...) in TGD inspired theory of consciousness.

1. In TGD framework the identification of qualia follows from the identification of quantum jump as a moment of consciousness. Just as quantum numbers characterize the physical state, the increments of quantum numbers characterize the quantum jump between two states. This leads to a capacitor model of the sensory receptor in which the sensory perception corresponds to a generalized di-electric breakdown in which various particles carrying some quantum numbers flow between electrodes and the change of the quantum numbers at second electrodes gives rise to the sensory quale in question.
2. It is important that sensory qualia are assigned to the sensory receptors rather than to the neural circuitry of brain as in standard neuroscience. This leads to objections (phantom leg for instance) which are circumvented in TGD based vision about 4-D brain. For instance, phantom leg would correspond to sensory memory resulting by sharing the mental image about pain residing in the geometric past when the leg still existed. A massive back-projection generating virtual sensory input from brain (or from the magnetic body via brain) is needed to build the actual perception as a kind of art-work by filtrating from the actual sensory input a lot of unessential stuff and amplifying the essential features.
3. The discovery of Callahan [?] that odor perception of insects seems to be based on IR light inspired my own the proposal that photons at IR frequencies could be involved with the odor

perception so that odor perception would be at molecular level seeing by IR light. Even hearing could involve similar “seeing” in appropriate frequency range. Massless extremals (topological light rays) would serve as kind of wave guides parallel to axons along which light would propagate as kind of laser beams between receptor and brain. This would also explain why the mediation of auditory input takes so rapidly.

4. I have also proposed frequency coding for the sensory qualia. The first proposal which I dubbed as “Spectroscopy of Consciousness” stated that cyclotron frequencies assignable to various biologically important ions -much below IR range- associated with as such correspond to sensory qualia. Later I gave up this idea and proposed that frequencies code provide only a symbolic representations- define their names- as one might say. The information about qualia and more general sensory data would be represented in terms of cyclotron frequencies inducing dynamical patterns of the cyclotron Bose-Einstein condensates of biologically important ions residing at the magnetic body receiving the sensory information.

Vibrational theory of odor perception

I attach a small piece of the article here to give a popular summary about the work of Luca Turin [J95].

Quantum physics may explain the mysterious biological process of smell, too, says biophysicist Luca Turin, who first published his controversial hypothesis in 1996 while teaching at University College London. Then, as now, the prevailing notion was that the sensation of different smells is triggered when molecules called odorants fit into receptors in our nostrils like three-dimensional puzzle pieces snapping into place. The glitch here, for Turin, was that molecules with similar shapes do not necessarily smell anything like one another. Pinanethiol [C10H18S] has a strong grapefruit odor, for instance, while its near-twin pinanol [C10H18O] smells of pine needles. Smell must be triggered, he concluded, by some criteria other than an odorant's shape alone.

What is really happening, Turin posited, is that the approximately 350 types of human smell receptors perform an act of quantum tunnelling when a new odorant enters the nostril and reaches the olfactory nerve. After the odorant attaches to one of the nerve's receptors, electrons from that receptor tunnel through the odorant, jiggling it back and forth. In this view, the odorant's unique pattern of vibration is what makes a rose smell rosy and a wet dog smell wet-doggy.

The article “A spectroscopic mechanism for primary olfactory perception” [J95] by Turin explains in detail his theory and various experimental tests. Here are the core ideas in more quantitative terms.

1. The theory originates from the proposal of Dyson proposed already 1938 that odor perception might rely on the vibrational spectrum of the odorant rather than its shape alone. The spectrum would be in the wave length range 2.5-10 μm corresponding to photon energies in the range 5 eV -125 eV. This vibrational spectrum would be excited by the current of electrons tunnelling from the receptor to the odorant molecule.
2. The proposal is that odor receptor can be regarded as a pair formed by a source and sink of electrons. If there is nothing between source and sink, tunnelling can occur if there is electronic energy state with same energy in both source and sink. If there is an odorant molecule between source and sink with vibrational energy E, tunnelling can occur indirectly: the electron can excite a vibrational state with this energy and tunnelling can occur only if the difference of electron energies in source and sink is E. Therefore the presence of odor molecule would be detected from the occurrence of the tunnelling and vibrational energy spectrum would characterize the odor molecule.

Comparison of Turin's model with TGD and Callahan's theory

One can compare the model of Turin with TGD based ideas.

1. The theory of Turin conforms at the general level with the receptor model. The “electrodes” of the sensory capacitor would correspond to the source and sink of electrons and the presence of the odorant molecule between the “electrodes” would induce the current. The current of

electrons from the source to the sink should induce the change of total quantum numbers defining the odor quale.

2. The first thing to notice is that the upper bound 5 eV for IR energies corresponds to the nominal value of the metabolic energy quantum identified as the energy liberated as proton drops from the atomic space-time sheet with $k = 137$ to a very large space-time sheet or the same process for electron Cooper at $k = 149$ space-time sheet. If Cooper pairs are involved, the latter process would occur in the length scale defined by the thickness of the lipid layer of the cell membrane (5 nm). The lower bound corresponds to a metabolic energy quantum assignable to $k = 139$ for protons and $k = 151$ transition for electrons (thickness of cell membrane).
3. Second point to notice is that TGD predicts a fractal hierarchy of spectra of metabolic energy quanta [K13] coming as $E(\Delta k, n) = 2^{-\Delta k} E_0 (1 - 2^{-n})$, $n = 1, 2, \dots$, converging to $E(\Delta k, \infty) = 2^{-\Delta k} E_0$ for given p-adic length scale characterized by the difference $\Delta k = k - k_0$. E_0 denotes the zero point kinetic energy of particle at space-time sheet with p-adic length scale $k = k_0$ and is inversely proportional to the mass of the particle. The transfer of electrons and/or protons between different space-time sheets with any perception for purely metabolic reasons. The simplest option is that since the electrons at the side of the source receive their energy in this manner, their energy spectrum is given by $E(\Delta k, n)$ (there is of course some resolution meaning a cutoff in n). The specificity of the receptor would require preference of some specific metabolic energy quanta $E(\Delta k, n)$. If this spectrum characterizes the receptor independently of its chemistry, then not only metabolic energy quanta but also the mechanism of sensory perception is universal. This proposal fails if the receptor has always same spectrum of $E(\Delta k, n)$ since all receptors would detect all odors.

It is interesting to relate the theory of Turin with the hypothesis of Callahan that the odor perception of insects uses IR light.

1. Callahan's work [?] suggests that the IR photons emitted by the odorant in the transitions between the vibrational states and received by the odor receptor are basically responsible for the odor perception. Turin in turn proposes that the pattern of vibrational excitations in the odor molecule characterizes the perception. These views are consistent if the pattern of vibrational excitations is in 1-1 correspondence with the flow pattern of electrons between different space-time sheets at the receptors if a kind of self-organization pattern results: this is expected to take place in presence of a metabolic energy feed.
2. In Callahan's model for the odor perception of insects the simplest odor receptor would "see" the IR light emitted by the odor molecules. Also Turin explains -with different assumptions- that the situation is analogous to that prevailing in retina in that there are receptors sensitive to characteristic energy ranges of photons. One would expect that the odor perception of insects is something very simple. The so called vomeronasal organ [J2] is known to be responsible for the perception of socially important odors not generating conscious experience at our level of self hierarchy but having important effect on behavior (perfume industry has long ago realized this!). Vomeronasal organ could utilize this kind of primitive odor receptors.
3. The rate for the spontaneous transitions emitting IR light could be rather low. A more advanced receptor would induce more transitions by using tunnelling electrons to excite vibrational energy levels in the odorant. This would be like using lamp to see better! The analogy with the transistor is also suggestive: the small base current induced by IR radiation generated by the odor molecule would be amplified in the process. Since the source contains electrons in excited states (at smaller space-time sheets), odor molecules could send negative energy photons dropping electrons to the large space-time sheet along which tunnelling is possible. Induced emission would cause a domino like flow of electrons and excitations of the vibrational states of the odor molecule as the counterpart of di-electric breakdown would take place.
4. What could then the physical correlates for the primary odor qualia? The increments of some quantum numbers assignable to electrons at the source should be in question. Could

the energies $E(k, n)$ characterizing the receptor define the primary odors? Odors and tastes are indeed very intimately related to metabolic activities. A natural consequence would be that besides the radiation generated by the transfer of electrons between space-time sheets would induce odor and perhaps also taste sensation. Organisms serve as food for other organisms so that an optimal detection of nutrients would be the outcome. The objection is that similar “metabolic qualia” would result in all receptors. This is not a problem if these qualia are qualia not conscious to us but conscious to neuronal selves. For instance, in TGD based model for visual colors color the increments of quantum numbers define the basic colors.

Could one assume that also other receptors use metabolic energy quanta as basic excitation energies?

1. The first objection is that similar “metabolic qualia” would result in all receptors. This is not a problem if these qualia are qualia not conscious to us but conscious to neuronal selves. For instance, in the TGD based model for visual colors the increments of color quantum numbers (in QCD sense!) define the basic colors, which means that colored particles must be in question (TGD variant of quark color implies the existence of scaled variants of QCD like physics and predicts that also electrons have colored excitations for which there is indeed a growing experimental evidence [K133]).
2. Second objection is that it does not seem possible to identify $E(k, n)$ as excitation energies in the case of vision. The relevant range of photon energies is [1.65, 3.3] eV. By scaling the metabolic energy quantum by a power of 2, the nominal values of relevant maximal metabolic energy quanta $E(k, n = \infty)$ are 2 eV and 4 eV. The series of energies approaching 2 eV below 2 eV is 1, 1.5, 1.75, ..., 2 eV so that the range below 2 eV representing red light would be covered. Above 2 eV the series is 2, 3, 3.50, ..., 4 eV so that the region above 2 eV (orange, yellow, green, blue, indigo, violet) would contain only single line at 3 eV (violet). If the incoming photon can kick the electron to an excited state with energy E_0 at the smaller space-time sheet the spectrum contains also the energies $E(k, n) + E_0$. For $E_0 = 1.3$ eV these excitation energies would come as 2.3, 2.8, 3.05, ... 3.3 eV and cover this range.

Isotope effect of olfaction as an additional guideline

The above considerations are still rather speculative and leave a lot of room for alternatives. The additional guideline leading to a surprisingly simple TGD inspired model of odor perception comes from the observation that flies can smell the difference between normal hydrogen and deuterium (see <http://tinyurl.com/6equps5>) [J107]. This is not in accordance with the standard theory of olfaction which says that olfaction relies on the shape of the molecule but conforms with the vibration theory of Luca Turin [J94, J95], who is one of the co-authors of the article [J70] reporting the discovery. The theory assumes that olfaction relies on molecular vibrational frequencies depending on the mass of the isotope.

1. Turin's theory

From Turin's video lecture (see <http://tinyurl.com/nupw1>) and Wikipedia article (see <http://tinyurl.com/a945lsu>) [J15] about vibration theory of olfaction one learns why reductionism is so nice when it can be applied.

1. If the molecular vibrations in a reasonable approximation reduce to independent vibrations assignable to various chemical bonds, the problem of predicting the odor of the molecule reduces to the calculation or measurement of the oscillation frequencies associated with the chemical bonds of between two atoms or between two molecules forming a bigger molecule as a composite. Near IR frequencies in 8-2.5 μm wavelength range associated with vibrational spectrum are inversely proportional to the reduced mass of the pair of atoms or molecules connected by the chemical bond and the IR frequencies related to rotational-vibrational transitions depending on more complex manner on the molecular mass are good candidates for inducing the olfactory qualia at least in the case of insects.

2. Situation is also simplified by the fact that only a finite range of frequencies is expected to induce odor sensation just as only finite range of frequencies induces visual percept. Hence the engineering of odors becomes possible by considering only some basic bonds. One can test the model by replacing the hydrogen with deuterium in some constituent of the molecule and this was done in the article referred above.
3. The odor of the molecule should be a superposition of the basic odors assignable to the basic chemical bonds just like visual color is a superposition of primary colors. One must however remember that the quantum phase transition inducing the odor sensation itself need not have anything to do with the IR photons and many frequencies could induce the same quantum phase transition. The innocent novice is also allowed to ask whether the harmonics of the fundamental oscillation frequency could give rise to the olfactory analogy of timbre distinguishing between different musical instruments and whether octaves correspond to more or less similar odor sensation. The following considerations suggest that the answer to these questions is negative.

In Turin's theory vibrational frequencies are interpreted in terms of a model of receptor based on the idea that electron tunnelling occurs between odor molecule and receptor and generates odor sensation if the energies of the electron states at the both sides are same. In general the ground state energies of the electron at the two sides are different but it can happen that the condition is satisfied for some excited state of electron of the acceptor so that odor perception is due to a tunnelling to an excited state. The model requires the fusion of the odorant molecule to the receptor so that there is a close relationship with the standard theory assuming lock-and-key mechanism.

2. Callahan's theory

The finding conforms also with the old discovery of Callahan that the olfaction of insects is analogous to seeing at IR frequencies. This hypothesis explains among other things the finding that insects seem to love candles [?].

If I have understood Callahan's theory correctly, the IR photons emitted by the odorant would induce transitions of electrons or Cooper pairs of the odor receptor. This would allow "radiative smelling" without a direct contact between odor molecules and olfactory receptors and at the first glance this seems like an unrealistic prediction. However, since the average power of radiation is proportional to $1/r^2$, where r is the distance between the receptor and molecule, radiative smelling would in practice be limited to rather short distances unless the radiation is guided. Maybe this could be tested experimentally by using coherent beam of IR light as a candidate for an artificial odorant.

3. TGD based theory

In TGD inspired theory of qualia one must distinguish between the sensory input inducing the quale and its secondary representation in terms of Josephson and cyclotron frequencies.

1. All qualia are coded (but not necessarily induced!) by various frequencies and communication using dark photons with various values of Planck constant meaning scaling down of visible basic frequencies is an essential element of communications at the level of biological body and between magnetic body and biological body. Josephson frequencies and cyclotron frequencies with so large Planck constant that energies are above thermal energy play a key role in the these communications. Note that cyclotron frequencies are inversely proportional to the mass of the ion so that isotope effect also at this level is predicted.

Josephson frequencies are assignable to cell membrane and one ends up with a nice model for the visual qualia assuming some new physics predicted by TGD. Josephson frequencies and their modulation (as in the case of hearing) should be highly relevant for all qualia.

2. The capacitor model for sensory qualia assumes that all qualia are generated via the quantum analog of dielectric breakdown in which particles with given quantum numbers characterizing the quale flow between the plates of the capacitor. For sensory receptors the capacitor is obtained by a multi-layered structure obtained by a multiple folding of the cell membrane so that the efficiency of the sensory receptor increases.

3. In Turin's model the second plate of the capacitor model would correspond to the odorant molecule. This does not however allow anything resembling di-electric breakdown. It is difficult to imagine how to achieve a quantum phase transition involving simultaneous tunnelling of a large number of electrons unless the receptor binds a large number of odorant molecules. Odor molecules should also form a quantum coherent state: a molecular analog of atomic Bose-Einstein condensate would be required. This would mean that only very special odor molecules could be smelled.
4. For the Callahan's variant of the theory the IR photons could excite the Cooper pairs of the other plate of the capacitor so that the tunnelling becomes possible and quantum variant of di-electric breakdown can take place. This model is consistent also with the assumption that cell membrane acts as a Josephson junction and fundamental sensory capacitor. The energy of electron gained in the electric field of the cell membrane is in the range 0.04-0.08 eV which indeed corresponds to IR frequencies. The variation of the membrane potential would give rise to the spectrum of basic odors. Roughly one octave of frequencies could be smelled if the cell membrane defines the fundamental nose smelling the energy of electron.

This option allows also the coding of odors by IR frequencies themselves so that brain could generate virtual odors by sending quantum coherent IR light to the odor receptors. This would explain odor hallucinations (and also other sensory hallucinations) as virtual percepts generated by brain itself. This sensory feedback would be absolutely essential for building up of standardized sensory percepts.

5. The difference between visual and odour receptors would be that the ground states of the cell membrane would correspond to near to vacuum extremals *resp.* far from vacuum extremals and therefore Josephson frequencies would be in visible *resp.* IR range respectively.

4.6.8 Is It Possible To See Without Brain?

Science News (see <http://tinyurl.com/ch2ppzo>) [J8] tells about a finding that transplanted eyes located far outside the head of vertebrate can see without a direct connection to brain. The connection to spine is however present.

The experimenters surgically removed donor embryo eye primordia, marked them with fluorescent proteins, and grafted them into the posterior region of recipient embryos. This induced the growth of the ectopic eyes. The natural eyes of recipients were removed. Fluorescent spectroscopy revealed the natural innervation patterns but none of the animals developed connections to brain.

To determine whether the animals having only ectopic eyes could see the training system was divided to quadrants of water illuminated by either red or blue LED light, and experimenters gave slight electric shocks in a particular quadrant. What was found that about 19 per cent of animals with optic nerves connected to the spine learned to avoid the quadrant in which they received electric shocks.

What experiments show that it is possible to see without neural connections to brain. The question is whether only the spinal cord or also the brain was involved with the learning. Probably neuroscientist could immediately answer this question but for an innocent layman like me the answer is far from obvious. Experimenters seem to think that brain is involved. As Douglas J. Blackinton, the first author of the paper (see <http://tinyurl.com/ybo4yydy>) "Ectopic Eyes Outside the Head in Xenopus Tadpoles Provide Sensory Data For Light-Mediated Learning," in the February 27 issue of the Journal of Experimental Biology [J27], states "Here, our research reveals the brain's remarkable ability, or plasticity, to process visual data coming from misplaced eyes, even when they are located far from the head."

If brain is involved and the learned response is not a mere reflex involving only the spine, there must be information transfer to brain - perhaps along spine - but not as nerve pulses.

In TGD framework these findings inspire several questions.

1. Does the ability to see colors mean that visual colors are perceived at the level of retina rather than brain? The phenomenon of phantom limb supports strongly the standard view that various qualia emerge at the level of brain. On the other hand, the almost-prediction of TGD inspired theory of consciousness is that the primary sensory percept - and therefore

also color qualia - can be assigned with the sensory organs. In TGD framework brain and body are 4-dimensional so that the pain in non-existing limb would be pain in the real limb of the geometric past.

Brain would build cognitive representations - standardized mental images - about the sensory input by decomposing the perceptive field to objects. Brain would of course induce also motor response by associating to these standardized mental images motor actions.

2. In order to build standardized mental images brain would generate feedback as a virtual sensory input to the sensory receptors. Virtual sensory input would be realized using what I have called dark photons having “topological light rays” as space-time correlates and assignable to the magnetic flux tubes connecting body parts together. Two new notions are involved: magnetic body - the primary intentional agent - and the signalling using photons, which are dark in the sense that they are characterized by a large effective value \hbar_{eff} of Planck constant coming as an integer multiple of \hbar so that for say energy of visible photon the wavelength can be much longer than micrometer.
3. It has of course been known for a long time that EEG carries precise information about the state of brain, and the natural question is why so? Magnetic body must receive data from biological body and the hypothesis is that EEG and its variants and possible scaled variants of EEG involving dark photons with large enough value of Planck constant to make their energies higher than thermal energy make this communications possible. Dark photons would be assigned to what I have used to call “topological light rays” assignable to magnetic flux tubes. The basic functions of EEG would therefore be communication to and control by magnetic body.

For instance, quite recent experiment (see <http://tinyurl.com/boljuyh> [J67, J7] involved two rats as model animals. The first rat learned to press one of the two levers in response to a light signal over the correct level to get the reward. Second rat received the EEG response of the first rat and learned to respond in the same manner on basis of this response only so that this sensory response served as a virtual sensory or cognitive input for it.

Magnetic body would generate also motor response using brain as a control instrument. Is the motor response in the recent case a kind of reflex action using only spine? Or are brain and magnetic body involved? Certainly the magnetic body could use brain as an intermediate control instrument. How much of the plasticity usually assigned with brain is actually flexibility of the magnetic body? And who is learning: is it brain or the magnetic body?

4. The communication using dark photons and the presence of magnetic body would make possible the participation of also brain to the learning process. For instance, the communication from the ectopic eye to brain could utilize quantum coherent dark photons travelling along the route ectopic eye \rightarrow appropriate layer of magnetic body \rightarrow brain. One can imagine also a dark photon communication along magnetic flux tubes parallel to spine.

4.6.9 How Are The Visual Percepts Constructed?

How does visual system analyze the incoming visual information and reconstruct from it a (highly artistic) picture of the external world? I encountered this problem for the first time for about 35 years ago while listening some lecture about what happens in retina. I was working with my thesis as an unemployed in a job with the (hidden for me) purpose to make me capable of getting a job in a real world (as a person suffering from a tendency to use my brains to thinking I was (and still am) labelled as a kind of socially handicapped person: in former Soviet Union I would have been labelled as a paranoid). The job itself was a purely formal duty and I was allowed to prepare my thesis rather freely (this would not be possible nowadays). I had also opportunity to listen lectures and this particular lecture series about neuroscience by Kari Kaila has teased me since then.

1. In the primary visual cortex there are so called orientation columns <http://tinyurl.com/y9c931q7>. The are geometrically flat slabs parallel to each other and orthogonal to the surface of the cortex being arranged like slices of bread. The neurons inside the columns are highly

discriminatory for visual orientations and their motion. Wikipedia article also mentions pinwheels: orientation columns characterized by different orientation angles meet at singular points. This bring in mind radial lines emanating from origin and defining discretization of the azimuthal angle.

This sounded very strange to me. Why not divide visual field to small cycles or squares and be sensitive to the light in a particular square defining the bit?

2. I learned that there are also simple and complex cells. Simple cells are sensitive to a particular line. Complex cells are sensitive to all lines with same direction.
3. I was also told that ganglions in retina have receptive fields. There are ganglions with on-center and off-center receptive fields. There is also a saccadic motion (<http://tinyurl.com/n3g3g5>), which is essential for visual consciousness: if it is prevented, subject persons first begins to see just darkness and eventually the visual consciousness fades away.

How to integrate these pieces to a coherent picture? During morning hours this problem popped up in my mind and I got some ideas and decided to check from Wikipedia what is known. I of course thought that this whole thing has been well-understood for decades and maybe it is! If so, I am making myself a fool: it does not however matter much at this age! I found an article about orientations columns (<http://tinyurl.com/y9c931q7>) containing a brief mention about a model for how the orientation map is constructed.

So called Moire interference (see <http://tinyurl.com/yd2jsk32>) of identical or nearly identical patterns rotated with respect to each other by an angle produces a non-localized representation of a definite orientation. By putting the visual representation associated with approximately hexagonal lattices formed by on-centre and off-centre ganglions, one would obtain a representation of orientation somehow. I must be honest: I did not understand the idea at all! Is this really so complex? There was a reference to an article in Nature: Paik, S., Ringach, D. L. (2011): Retinal origin of orientation maps in the visual cortex. Nature Neuroscience, 14(7), 919-925. I do not have access to this article so that I can continue making naïve questions and stupid arguments.

1. Primary visual cortex performs the roughest processing of visual information. What are the simplest possible visual representations of the external world? Drawings of course. Painters make first a a sketch. We have cartoons. Visualizations are typically 2-D drawings. It would not be surprising if visual system would not obey the same strategy. In finite resolution they consist of pieces of lines forming what looks like continuous structures when the length of basic piece is short enough as anyone who has used drawing programs knows. Maybe brain and retina first build this kind of representation and add colours and other details later.
2. Could ganglia or possible linear structures formed from them effectively see through slits? They would be specialized to detect the presence of this kind of lines of some minimal length defining the resolution and going through through the centre of retina. When the line is parallel to the slit associated with the detector, the line detector sends nerve pulses to brain.
3. There is a problem. If the orientation of eye remains fixed, the line detector sees only the lines going through the normal of the retina at its centre and usually sees nothing. Most of visual field would remain unseen.

Saccadic motion saves the situation. When the normal of the line detector intersects the line of visual field with a proper orientation, it detects a line. For a given light intensity the input is maximal if the line is longer than the maximal length of line source for which detector is sensitive. The total intensity of incoming light through the slit is enough to build the representation. The output is bit telling whether a piece of line is there or not.

4. These inputs from slit detectors would be the basic inputs fed to the complex cells forming representations of the lines. In visual cortex the information from the orientation of retina combined with the bits produced by slit detectors during a saccadic motion lasting so long a period that large enough number of orientations of normal are scanned, are combined to a drawing.

$T = .1$ seconds is the croon of time for sensory percepts. and is the natural guess for this period of integration. The maximal angular speed of saccadic motion is for humans about

900 degrees/second making 90 degrees per time interval T (see <http://tinyurl.com/n3g3g5>).

Certainly there must exist a feedback from brain favoring preferred saccades using already existing information about the distribution of lines so that for targets which are stationary saccades would go along the lines of the already existing picture and detect if changes have occurred. The signals from orientation columns of primary cortex might be important part of this feedback.

5. If the object remains in good approximation at rest during this period, a drawing about the external world is obtained as an outcome. The simplest guess is that orientation column at particular point of visual cortex corresponds to a point in the visual field and if there is line of defined direction going through that point of visual field, simple cell sensitive to that orientation receives input.
6. Could ganglia themselves see the world through a slit? One can argue that if this were the case, it would have been observed experimentally. I tend to agree. One can of course ask whether saccadic motion necessary for visual consciousness effectively blurs the visual field of the ganglion so that it is disk of radius defined by the maximal length of line for which ganglion is sensitive.

The simplest and probably the correct assumption is that ganglia indeed detect spots of light or absence of it. Line detectors would correspond to lines formed by ganglia or perhaps similar structures at higher levels of the neural hierarchy.

Since I love magnetic flux tubes, I cannot resist the temptation to connect the ganglia by flux tubes to form these lines so that one would have a grid lines of ganglia analogous to a the radial lines of a coordinate grid of cylindrical coordinates with origin at the centre of retina. Peripheral regions would correspond to a poorer resolution if this is the case. Maybe macroscopic quantum coherence would enter the stage here and allow to bind the percepts about spots to a percept about line.

Of, course this idea is just a first guess reflecting my deep ignorance about how visual representations are formed, and certainly the details, if not the whole idea, are wrong.

4.7 TGD Based Models For Cell Membrane As Sensory Receptor

The emergence of zero energy ontology, the explanation of dark matter in terms of a hierarchy of Planck constants requiring a generalization of the notion of embedding space, the view about life as something in the intersection of real and p-adic worlds, and the notion of number theoretic entanglement negentropy lead to the breakthrough in TGD inspired quantum biology and also to the a view of qualia and sensory representations including hearing.

One of the basic challenge has been to construct a quantitative model for cell membrane.

1. The first model was based on the assumption that long range weak forces however play a key role [K13]. They are made possible by the exotic ground state represented as almost vacuum extremal of Kähler action for which classical em and Z^0 fields are proportional to each other whereas for the standard ground state classical Z^0 fields are very weak. Neutrinos are present but it seems that they do not define cognitive or Boolean representations in the time scales characterizing neural activity. Electrons and quarks for which the time scales of causal diamonds correspond to fundamental biorhythms - one of the key observations during last years- take this role. The essential element is that the energies of the Josephson photons are in visible range. This would explain bio-photons and even why the frequencies assignable to visual receptors. Skeptic can of course argue that the energies at which receptors are most sensitive to incoming light need not have anything to do with the Josephson frequencies. Skeptic might be right but it is interesting to see if this hypothesis might work.

A possible problem is that Weinberg angle must be assumed to be much smaller in the near vacuum extremal phase than in standard model if one wants to explain the photon

energies at which color receptors have maximum absorption assuming *same voltage* over the Josephson junction defined by the receptor protein. A way out of problem is to assume that the voltage through the transmembrane protein depends on the ion (Na^+ , K^+ , Cl^- or Ca^{++}) characterizing the color receptor and is therefore different for the color receptors.

2. Second model is based on Gerald Pollack's findings about the fourth phase of water and exclusion zones [L25]. These zones inspire a model for pre-biotic cells. The outcome is a modification of the simplest model of Josephson junction. Besides resting potential also the difference between cyclotron energies between the two sides of the membrane plays a key role. This model allows to understand what happens in metabolism in terms of a quantum model replacing the thermodynamical model for cell membrane with its quantal "square root" inspired by Zero Energy Ontology. The model allows also to understand bio-photons as decay products of dark photons.
3. The success of the latter model does not of course mean that the weak forces could not be important in cell membrane scale and the realistic model could be a hybrid of these two models. The inclusion of Z^0 contribution to the effective magnetic field could also to the fact that the endogenous magnetic field deduced from Blackman's experiments is $B_{end} = 2B_E/5$ rather than B_E (Earth's magnetic field).

4.7.1 Could Cell Correspond To Almost Vacuum Extremal?

The question whether cell could correspond almost vacuum extremal of Kähler action was the question which led to the realization that the frequencies of peak sensitivity for photoreceptors correspond to the Josephson frequencies of biologically important ions if one accepts that the value of the Weinberg angle equals to $\sin^2(\theta_W) = .0295$ instead of the value .23 in the normal phase, in which the classical electromagnetic field is proportional to the induced Kähler form of CP_2 in a good approximation. The assumption about the value of Weinberg angle can be used as the basic objection against the model. Another implication made possible by the large value of Planck constant is the identification of Josephson photons as the counterparts of bio-photons one one hand and those of EEG photons on the other hand. These observation in turn led to a detailed model of sensory qualia and of sensory receptor. Therefore the core of this argument deserves to be represented also here although it has been discussed in [K96].

Cell membrane as almost vacuum extremal

Although the fundamental role of vacuum extremals for quantum criticality and life has been obvious from the beginning, it took a long time to realize how one could model living cell as this kind of system.

1. Classical electric fields are in a fundamental role in biochemistry and living biosystems are typically electrets containing regions of spontaneous electric polarization. Fröhlich [J76] proposed that oriented electric dipoles form macroscopic quantum systems with polarization density serving as a macroscopic order parameter. Several theories of consciousness share this hypothesis. Experimentally this hypothesis has not been verified.
2. TGD suggests much more profound role for the unique di-electric properties of the biosystems. The presence of strong electric dipole fields is a necessary prerequisite for cognition and life and could even force the emergence of life. Strong electric fields imply also the presence of the charged wormhole BE condensates: the surface density of the charged wormholes on the boundary is essentially equal to the normal component of the electric field so that wormholes are in some sense "square root" of the dipole condensate of Fröhlich! Wormholes make also possible pure vacuum polarization type dipole fields: in this case the magnitudes of the em field at the two space-time sheets involved are same whereas the directions of the fields are opposite. The splitting of wormhole contacts creates fermion pairs which might be interpreted as cognitive fermion pairs. Also microtubules carry strong longitudinal electric fields.

This formulation emerged much before the identification of ordinary gauge bosons and their superpartners as wormhole contacts. In the recent view about TGD based on the weak

form of electric-magnetic duality wormhole magnetic flux tubes having magnetically charged wormhole throats at their ends could be interpreted as scaled up variants of elementary particles having a large value of Planck constant.

Cell membrane is the basic example about electret and one of the basic mysteries of cell biology is the resting potential of the living cell. Living cell membranes carry huge electric fields: something like 10^7 Volts per meter. For neuron resting potential corresponds to about 0.07 eV energy gained when unit charge travels through the membrane potential. In TGD framework it is not at all clear whether the presence of strong electromagnetic field necessitates the presence of strong Kähler field. The extremely strong electric field associated with the cell membrane is not easily understood in Maxwell's theory and almost vacuum extremal property could change the situation completely in TGD framework.

1. The configuration could be a small deformation of vacuum extremal so that the system would be highly critical as one indeed expects on basis of the general vision about living matter as a quantum critical system. For vacuum extremals classical em and Z^0 fields would be proportional to each other. The second half of Maxwell's equations is not in general satisfied in TGD Universe and one cannot exclude the presence of vacuum charge densities in which case elementary particles as the sources of the field would not be necessarily. If one assumes that this is the case approximately, the presence of Z^0 charges creating the classical Z^0 fields is implied. Neutrinos are the most candidates for the carrier of Z^0 charge. Also nuclei could feed their weak gauge fluxes to almost non-vacuum extremals but not atomic electrons since this would lead to dramatic deviations from atomic physics. This would mean that weak bosons would be light in this phase and also Weinberg angle could have a non-standard value.
2. There are also space-time surfaces for CP_2 projection belongs to homologically non-trivial geodesic sphere. In this case classical Z^0 field can vanish and the vision has been that it is sensible to speak about two basic configurations.
 - (a) Almost vacuum extremals (homologically trivial geodesic sphere).
 - (b) Small deformations of non-vacuum extremals for which the gauge field has pure gauge Z^0 component (homologically non-trivial geodesic sphere).

The latter space-time surfaces are excellent candidates for configurations identifiable as TGD counterparts of standard electroweak physics. Note however that the charged part of electroweak fields is present for them.

3. To see whether the latter configurations are really possible one must understand how the gauge fields are affected in the color rotation.
 - (a) The action of color rotations in the holonomy algebra of CP_2 is non-trivial and corresponds to the action in $U(2)$ sub-group of $SU(3)$ mapped to $SU(2)_L \times U(1)$. Since the induced color gauge field is proportional to Kähler form, the holonomy is necessary Abelian so that also the representation of color rotations as a sub-group of electro-weak group must correspond to a local $U(1)$ sub-group local with respect to CP_2 point.
 - (b) Kähler form remains certainly invariant under color group and the right handed part of Z^0 field reducing to $U(1)_R$ sub-algebra should experience a mere Abelian gauge transformation. Also the left handed part of weak fields should experience a local $U(1)_L$ gauge rotation acting on the neutral left handed part of Z^0 in the same manner as it acts on the right handed part. This is true if the $U(1)_L$ sub-group does not depend on point of CP_2 and corresponds to Z^0 charge. If only Z^0 part of the induced gauge field is non-vanishing as it can be for vacuum extremals then color rotations cannot change the situation. If Z^0 part vanishes and non-vacuum extremal is in question, then color rotation rotation of W components mixing them but acts as a pure $U(1)$ gauge transformation on the left handed component.

- (c) It might not be without importance that for any partonic 2-surface induced electro-weak gauge fields have always $U(1)$ holonomy, which could allow to define what neutral part of induced electroweak gauge field means locally. This does not however hold true for the 4-D tangent space distribution. In any case, the cautious conclusion is that there are two phases corresponding to nearly vacuum extremals and small deformations of extremals corresponding to homologically non-trivial geodesic spheres for which the neutral part of the classical electro-weak gauge field reduces to photon field.
4. The unavoidable presence of long range Z^0 fields would explain large parity breaking in living matter, and the fact that neutrino Compton length is of the order of cell size would suggest the possibility that within neutrino Compton electro-weak gauge fields or even longer scales could behave like massless fields. The explanation would be in terms of the different ground state characterized also by a different value of Weinberg angle. For instance, of the p-adic temperature of weak bosons corresponds to $T_p = 1/2$, the mass scale would be multiplied by a factor $\sqrt{M_{89}}$ and Compton lengths of weak bosons would be around 10^{-4} meters corresponding to the size scale of a large neuron. If the value of Planck constant is also large then the Compton length increases to astrophysical scale.
5. From the equations for classical induced gauge fields in terms of Kähler form and classical Z^0 field (see the appendix of any of the books about TGD)

$$\gamma = 3J - \frac{p}{2}Z^0 \quad , \quad Q_Z = I_L^3 - pQ_{em} \quad , \quad p = \sin^2(\theta_W) \quad (4.7.1)$$

it follows that for the vacuum extremals the part of the classical electro-weak force proportional to the electromagnetic charge vanishes for $p = 0$ so that only the left-handed couplings to the weak gauge bosons remain. The absence of electroweak symmetry breaking and vanishing or at least smallness of p would make sense below the Compton length of dark weak bosons. If this picture makes sense it has also implications for astrophysics and cosmology since small deformations of vacuum extremals are assumed to define the interesting extremals. Dark matter hierarchy might explain the presence of unavoidable long ranged Z^0 fields as being due to dark matter with arbitrarily large values of Planck constant so that various elementary particle Compton lengths are very long.

6. The simplest option is that the dark matter -say quarks with Compton lengths of order cell size and Planck constant of order $10^7 \hbar_0$ - are responsible for dark weak fields making almost vacuum extremal property possible. The condition that Josephson photons correspond to EEG frequencies implies $\hbar \sim 10^{13} \hbar_0$ and would mean the scaling of intermediate gauge boson Compton length to that corresponding to the size scale of a larger neuron. The quarks involved with DNA as topological quantum computer model could be in question and membrane potential might be assignable to the magnetic flux tubes. The ordinary ionic currents through cell membrane -having no coupling to classical Z^0 fields and not acting as its source- would be accompanied by compensating currents of dark fermions taking care that the almost vacuum extremal property is preserved. The outcome would be large parity breaking effects in cell scale from the left handed couplings of dark quarks and leptons to the classical Z^0 field. The flow of Na^+ ions during nerve pulse could take along same dark flux tube as the flow of dark quarks and leptons. This near vacuum extremal property might be fundamental property of living matter at dark space-time sheets at least.

Ionic Josephson frequencies defined by the resting potential for nearly vacuum extremals

If cell membrane corresponds to an almost vacuum extremal, the membrane potential is replaced with an effective restoring potential containing also the Z^0 contribution proportional to the ordinary resting potential. The surprising outcome is that one could understand the preferred frequencies for photo-receptors [J12] as Josephson frequencies for biologically important ions. Furthermore, most Josephson energies are in visible and UV range and the interpretation in terms of

$E(Ion)/eV$	$V = -40 \text{ mV}$	$V = -60 \text{ mV}$	$V = -70 \text{ mV}$
Na^+	1.01	1.51	1.76
Cl^-	1.40	2.11	2.46
K^+	1.64	2.47	2.88
Ca^{+2}	1.68	2.52	2.94

Table 4.1: Values of the Josephson energy of cell membrane for some values of the membrane voltage for $p = .23$. The value $V = -40 \text{ mV}$ corresponds to the resting state for photoreceptors and $V = -70 \text{ mV}$ to the resting state of a typical neuron.

bio-photons is suggestive. If the value of Planck constant is large enough Josephson frequencies are in EEG frequency range so that bio-photons and EEG photons could be both related to Josephson photons with large \hbar .

1. One must assume that the interior of the cell corresponds to many fermion state -either a state filled with neutrinos up to Fermi energy or Bose-Einstein condensate of neutrino Cooper pairs creating a harmonic oscillator potential. The generalization of nuclear harmonic oscillator model so that it applies to multi-neutrino state looks natural.
2. For exact vacuum extremals elementary fermions couple only via left-handed isospin to the classical Z^0 field whereas the coupling to classical em field vanishes. Both K_+ , Na_+ , and Cl_- $A - Z = Z + 1$ so that by p-n pairing inside nucleus they have the weak isospin of neutron (opposite to that of neutrino) whereas Ca_{++} nucleus has a vanishing weak isospin. This might relate to the very special role of Ca_{++} ions in biology. For instance, Ca_{++} defines an action potential lasting a time of order .1 seconds whereas Na_+ defines a pulse lasting for about 1 millisecond [J3]. These time scales might relate to the time scales of CDs associated with quarks and electron.
3. The basic question is whether only nuclei couple to the classical Z^0 field or whether also electrons do so. If not, then nuclei have a large effective vector coupling to em field coming from Z^0 coupling proportional to the nuclear charge increasing the value of effective membrane potential by a factor of order 100. If both electrons and nuclei couple to the classical Z^0 field, one ends up with difficulties with atomic physics. If only quarks couple to the Z^0 field and one has $Z^0 = -2\gamma/p$ for vacuum extremals, and one uses average vectorial coupling $\langle I_L^3 \rangle = \pm 1/4$ with + for proton and - for neutron, the resulting vector coupling is following

$$\begin{aligned} \left(\frac{Z - N}{4} - pZ\right)Z^0 + q_{em}\gamma &= Q_{eff}\gamma, \\ Q_{eff} &= -\frac{Z - N}{2p} + 2Z + q_{em}. \end{aligned} \quad (4.7.2)$$

Here γ denotes em gauge potential. For K^+ , Cl^- , Na^+ , Ca^{++} one has $Z = (19, 17, 11, 20)$, $Z - N = (-1, -1, -1, 0)$, and $q_{em} = (1, -1, 1, 2)$. **Table 4.1** below gives the values of Josephson energies for some values of resting potential for $p = .23$. Rather remarkably, they are in IR or visible range.

Are photoreceptors nearly vacuum extremals?

In Hodgkin-Huxley model ionic currents are Ohmian currents. If one accepts the idea that the cell membrane acts as a Josephson junction, there are also non-dissipative oscillatory Josephson currents of ions present, which run also during flow equilibrium for the ionic parts of the currents. A more radical possibility is that the dominating parts of the ionic currents are oscillatory Josephson currents so that no metabolic energy would be needed to take care that density gradients for ions are preserved. Also in this case both nearly vacuum extremals and extremals with nearly vanishing

Z^0 field can be considered. Since sensory receptors must be highly critical the natural question is whether they could correspond to nearly vacuum extremals. The quantitative success of the following model for photoreceptors supports this idea.

Photoreceptors can be classified to three kinds of cones responsible for color vision and rods responsible for black-white vision. The peak sensitivities of cones correspond to wavelengths (405, 535, 565) nm and energies (3.06, 2.32, 2.19) eV. The maximum absorption occurs in the wave length range 420-440 nm, 534-545 nm, 564-580 nm for cones responsible for color vision and 498 nm for rods responsible black-white vision [J12, L66]. The corresponding photon energies are (2.95, 2.32, 2.20) eV for color vision and to 2.49 eV for black-white vision. For frequency distribution the maxima are shifted from these since the maximum condition becomes $dI/d\lambda + 2I/\lambda = 0$, which means a shift to a larger value of λ , which is largest for smallest λ . Hence the energies for maximum absorbance are actually lower and the downwards shift is largest for the highest energy.

From **Table 4.1** it is clear that the energies of Josephson photons are in visible range for reasonable values of membrane voltages, which raises the question whether Josephson currents of nuclei in the classical em and Z^0 fields of the cell membrane could relate to vision.

Consider first the construction of the model.

1. Na^+ and Ca^{++} currents are known to present during the activation of the photoreceptors. Na^+ current defines the so called dark current [J12] reducing the membrane resting potential below its normal value and might relate to the sensation of darkness as eyes are closed. Hodgkin-Huxley model predicts that also K^+ current is present. Therefore the Josephson energies of these three ion currents are the most plausible correlates for the three colors.
2. One ends up with the model in the following manner. For Ca^{++} the Josephson frequency does not depend on p and requiring that this energy corresponds to the energy 2.32 eV of maximal sensitivity for cones sensitive to green light fixes the value of the membrane potential during hyper-polarization to $V = .055$ V, which is quite reasonable value. The value of the Weinberg angle parameter can be fixed from the condition that other peak energies are reproduced optimally. The result of $p = .0295$.

The predictions of the model come as follows summarized also by the **Table 10.1** below.

1. The resting potential for photoreceptors is $V = -40$ mV [J13]. In this case all Josephson energies are below the range of visible frequencies for $p = .23$. Also for maximal hyper-polarization Na^+ Josephson energy is below the visible range for this value of Weinberg angle.
2. For $V = -40$ mV and $p = .0295$ required by the model the energies of Cl^- and K^+ Josephson photons correspond to red light. 2 eV for Cl^- corresponds to a basic metabolic quantum. For Na^+ and Ca^{++} the wave length is below the visible range. Na^+ Josephson energy is below visible range. This would conform with the interpretation of Na^+ current as a counterpart for the sensation of darkness.
3. For $V = -55$ mV - the threshold for the nerve pulse generation- and for $p = .0295$ the Josephson energies of Na^+ , Ca^{++} , and K^+ correspond to the peak energies for cones sensitive to red, green, and blue respectively. Also Cl^- is in the blue region. Ca^{++} Josephson energy can be identified as the peak energy for rods. The increase of the hyper-polarization to $V = -59$ mV reproduces the energy of the maximal wave length response exactly. A possible interpretation is that around the criticality for the generation of the action potential ($V \simeq -55$ mV) the qualia would be generated most intensely since the Josephson currents would be strongest and induce Josephson radiation inducing the quale in other neurons of the visual pathway at the verge for the generation of action potential. This supports the earlier idea that visual pathways defines a neural window. Josephson radiation could be interpreted as giving rise to bio-photons (energy scale is correct) and to EEG photons (for large enough values of \hbar the frequency scales is that of EEG).
4. In a very bright illumination the hyper-polarization is $V = -65$ mV [J13], which the normal value of resting potential. For this voltage Josephson energies are predicted to be in UV region except in case of Ca^{++} . This would suggests that only the quale "white" is generated at the level of sensory receptor: very intense light is indeed experienced as white.

Ion	Na^+	Cl^-	K^+	Ca^{+2}
$E_J(.04 \text{ mV}, p = .23)/eV$	1.01	1.40	1.51	1.76
$E_J(.065 \text{ V}, p = .23)/eV$	1.64	2.29	2.69	2.73
$E_J(40 \text{ mV}, p = .0295)/eV$	1.60	2.00	2.23	1.68
$E_J(50 \text{ mV}, p = .0295)/eV$	2.00	2.49	2.79	2.10
$E_J(55 \text{ mV}, p = .0295)/eV$	2.20	2.74	3.07	2.31
$E_J(65 \text{ mV}, p = .0295)/eV$	2.60	3.25	3.64	2.73
$E_J(70 \text{ mV}, p = .0295)/eV$	2.80	3.50	3.92	2.94
$E_J(75 \text{ mV}, p = .0295)/eV$	3.00	3.75	4.20	3.15
$E_J(80 \text{ mV}, p = .0295)/eV$	3.20	4.00	4.48	3.36
$E_J(90 \text{ mV}, p = .0295)/eV$	3.60	4.50	5.04	3.78
$E_J(95 \text{ mV}, p = .0295)/eV$	3.80	4.75	5.32	3.99
Color	R	G	B	W
E_{max}	2.19	2.32	3.06	2.49
energy-interval/eV	1.77-2.48	1.97-2.76	2.48-3.10	

Table 4.2: Table gives the prediction of the model of photoreceptor for the Josephson energies for typical values of the membrane potential. For comparison purposes the energies E_{max} corresponding to peak sensitivities of rods and cones, and absorption ranges for rods are also given. R, G, B, W refers to red, green, blue, white. The values of Weinberg angle parameter $p = \sin^2(\theta_W)$ are assumed to be .23 and .0295. The latter value is forced by the fit of Josephson energies to the known peak energies.

The model reproduces basic facts about vision assuming that one accepts the small value of Weinberg angle, which is indeed a natural assumption since vacuum extremals are analogous to the unstable extrema of Higgs potential and should correspond to small Weinberg angle. It deserves to be noticed that neutrino Josephson energy is 2 eV for $V = -50$ mV, which correspond to color red. 2 eV energy defines an important metabolic quantum.

It is interesting to try to interpret the resting potentials of various cells in this framework in terms of the Josephson frequencies of various ions.

1. The maximum value of the action potential is +40 mV so that Josephson frequencies are same as for the resting state of photoreceptor. Note that the time scale for nerve pulse is so slow as compared to the frequency of visible photons that one can consider that the neuronal membrane is in a state analogous to that of a photoreceptor.
2. For neurons the value of the resting potential is -70 mV. Na^+ and Ca^{++} Josephson energies 2.80 eV and 2.94 eV are in the visible range in this case and correspond to blue light. This does not mean that Ca^{++} Josephson currents are present and generate sensation of blue at neuronal level: the quale possibly generated should depend on sensory pathway. During the hyper-polarization period with -75 mV the situation is not considerably different.
3. The value of the resting potential is -95 mV for skeletal muscle cells. In this case Ca^{++} Josephson frequency corresponds to 4 eV metabolic energy quantum as **Table 4.1** shows.
4. For smooth muscle cells the value of resting potential is -50 mV. In this case Na^+ Josephson frequency corresponds to 2 eV metabolic energy quantum.
5. For astroglia the value of the resting potential is -80/-90 mV for astroglia. For -80 mV the resting potential for Cl^- corresponds to 4 eV metabolic energy quantum. This suggests that glial cells could also provide metabolic energy as Josephson radiation to neurons.
6. For all other neurons except photo-receptors and red blood cells Josephson photons are in visible and UV range and the natural interpretation would be as bio-photons. The bio-photons detected outside body could represent sensory leakage. An interesting question is whether the IR Josephson frequencies could make possible some kind of IR vision.

The basic criticism against the model is that the value of Weinberg angle must be by a factor of 1/10 smaller than the standard model value, and at this moment it is difficult to say anything about its value for nearly vacuum extremals.

A possible cure could be that the voltage is not same for different ions. This is possible since at microscopic level the Josephson junctions correspond to transmembrane proteins acting as channels and pumps. The membrane potential through receptor protein is different for color receptors. For this option one would have the correspondences

$Na^+ \leftrightarrow 2.19 \text{ eV (R) and } eV = 86.8 \text{ eV,}$

$Cl^- \leftrightarrow 2.32 \text{ eV (G) and } eV = 65.8 \text{ eV,}$

$K^+ \leftrightarrow 2.49 \text{ eV (W) and } eV = 60.2 \text{ eV,}$

$Ca^{++} \leftrightarrow 3.06 \text{ eV (B) and } eV = 67.3 \text{ meV.}$

For Na^+ the value of the membrane potential is suspiciously large.

It is interesting to look what happens when the model is generalized so that Josephson energy includes the difference of cyclotron energies at the two sides of the cell membrane and Weinberg angle has its standard model value.

1. Consider first *near to vacuum extremals*. In the formula for cyclotron frequencies in the effective magnetic field the factor Z/A in the formula of is replaced with

$$\frac{\frac{N-Z}{2p} + 2Z + q_{em}}{A},$$

which is not far from unity so that the cyclotron frequency would be near to that for proton for all ions. Also neutral atoms would experience classical and magnetic Z^0 fields. Cyclotron frequency would be almost particle independent so that cyclotron contribution gives an almost constant shift to the generalized Josephson energy. When the difference of cyclotron energies vanishes, the model reduces to that discussed above.

The weak independence of the cyclotron frequency on particle properties does not conform with the idea that EEG bands correspond to bosonic ions or Cooper pairs of fermionic ions.

2. For *far from vacuum extremals* the proportionality of cyclotron energy to h_{eff} and B_{end} allows easy reproduction the energies for which photon absorption is maximal if one allows the cyclotron energies to differ at the two sides of the membrane for sensory receptors.

4.7.2 Pollack's Findings About Fourth Phase Of Water And The Model Of Cell

The discovery of negatively charged exclusion zone formed in water bounded by gel phase has led Pollack to propose the notion of gel like fourth phase of water. In this article this notion is discussed in TGD framework. The proposal is that the fourth phase corresponds to negatively charged regions - exclusion zones - with size up to 100-200 microns generated when energy is fed into the water - say as radiation, in particular solar radiation. The stoichiometry of the exclusion zone is $H_{1.5}O$ and can be understood if every fourth proton is dark proton residing at the flux tubes of the magnetic body assignable to the exclusion zone and outside it.

This leads to a model for prebiotic cell as exclusion zone. Dark protons are proposed to form dark nuclei whose states can be grouped to groups corresponding to DNA, RNA, amino-acids, and tRNA and for which vertebrate genetic code is realized in a natural manner. The voltage associated with the system defines the analog of membrane potential, and serves as a source of metabolic energy as in the case of ordinary metabolism. The energy is liberated in a reverse phase transition in which dark protons transform to ordinary ones. Dark proton strings serve as analogs of basic biopolymers and one can imagine analog of bio-catalysis with enzymes replaced with their dark analogs. The recent discovery that metabolic cycles emerge spontaneously in absence of cell support this view.

One can find a biographical sketch [I39] (<http://tinyurl.com/ycqtuchp>) giving a list of publications containing items related to the notions of exclusion zone and fourth phase of water discussed in the talk.

Pollack's findings

I list below some basic experimental findings about fourth gel like phase of water made in the laboratory led by Gerald Pollack [L25].

1. In water bounded by a gel a layer of thickness up to 100-200 microns is formed. All impurities in this layer are taken outside the layer. This motivates the term "exclusion zone". The layer consists of layers of molecular thickness and in these layers the stoichiometry is $H_{1.5}O$. The layer is negatively charged. The outside region carries compensating positive charge. This kind of blobs are formed in living matter. Also in the splitting of water producing Brown's gas negatively charged regions are reported to emerge [H11, H1].
2. The process requires energy and irradiation by visible light or thermal radiation generates the layer. Even the radiation on skin can induce the phase transition. For instance, the blood flow in narrow surface veins requires metabolic energy and irradiation forces the blood to flow.
3. The layer can serve as a battery: Pollack talks about a form of free energy deriving basically from solar radiation. The particles in the layer are taken to the outside region, and this makes possible disinfection and separation of salt from sea water. One can even understand how clouds are formed and mysteries related to the surface tension of water as being due the presence of the layer formed by $H_{1.5}O$.
4. In the splitting of water producing Brown's gas [H11, H1] having a natural identification as Pollack's fourth phase of water the needed energy can come from several alternative sources: cavitation, electric field, etc...

Dark nuclei and Pollack's findings

While listening the lecture of Pollack I realized that a model for dark water in term of dark proton sequences is enough to explain the properties of the exotic water according to experiments done in the laboratory of Pollack. There is no need to assume sequences of half-dark water molecules containing one dark proton each.

1. Model for the formation of exclusion zones

The data about formation of exclusion zones allows to construct a more detailed model for what might happen in the formation of exclusion zones.

1. The dark proton sequences with dark proton having size of order atomic nucleus would reside at the flux tubes of dark magnetic field which is dipole like field in the first approximation and defines the magnetic body of the negatively charged water blob. This explains the charge separation if the flux tubes have length considerably longer than the size scale of the blob which is given by size of small cell. In the model inspired by Moray B. King's lectures charge separation is poorly understood.
2. An interesting question is whether the magnetic body is created by the electronic currents or whether it consists of flux tubes carrying monopole flux: in the latter case no currents would be needed. This is obviously purely TGD based possibility and due to the topology of CP_2 .
3. This means that in the model inspired by the lectures of Moray B. King discussed above, one just replaces the sequences of partially dark water molecules with sequences of dark protons at the magnetic body of the $H_{1.5}O$ blob. The model for the proto-variants of photosynthesis and metabolism remain as such. Also now genetic code would be realized [K58, L3].
4. The transfer of impurities from the exclusion zone could be interpreted as a transfer of them to the magnetic flux tubes outside the exclusion zone as dark matter.

These primitive forms of photosynthesis and metabolism form could be key parts of their higher level chemical variants. Photosynthesis by irradiation would induce a phase transition generating dark magnetic flux tubes (or transforming ordinary flux tubes to dark ones) and the

dark proton sequences at them. Metabolism would mean burning of the resulting blobs of dark water to ordinary water leading to the loss of charge separation. This process would be analogous to the catabolism of organic polymers liberating energy. Also organic polymers in living matter carry their metabolic energy as dark proton sequences: the layer could also prevent their hydration. That these molecules are typically negatively charged would conform with the idea that dark protons at magnetic flux tubes carry the metabolic energy.

The liberation of energy would involve increase of the p-adic prime characterizing the flux tubes and reduction of Planck constant so that the thickness of the flux tubes remains the same but the intensity of the magnetic field is reduced. The cyclotron energy of dark protons is liberated in coherent fashion and in good approximation the frequencies of the radiation corresponds to multiples of cyclotron frequency: this prediction is consistent with that in the original model for the findings of Blackman and others [J31].

The phase transition generating dark magnetic flux tubes containing dark proton sequences would be the fundamental step transforming inanimate matter to living matter and the fundamental purpose of metabolism would be to make this possible.

2. Minimal metabolic energy consumption and the value of membrane potential

This picture raises a question relating to the possible problems with physiological temperature.

1. The Josephson radiation generated by cell membrane has photon energies coming as multiples of ZeV , where V is membrane potential about .06 V and $Z = 2$ is the charge of electron Cooper pair. This gives $E = .12$ eV.
2. There is a danger that thermal radiation masks Josephson radiation. The energy for photons at the maximum of the energy density of blackbody radiation as function of frequency is given as the maximum of function $x^3/(e^x - 1)$, $x = E/T$ given by $e^{-x} + x/3 - 1 = 0$. The maximum is given approximately by $x = 3$ and thus $E_{max} \simeq 3T$ (in units $c = 1, k_B = 1$). At physiological temperature $T = 310$ K (37 C) this gives .1 eV, which is slightly below Josephson energy: living matter seems to have minimized the value of Josephson energy - presumably to minimize metabolic costs. Note however that for the thermal energy density as function of *wavelength* the maximum is at $E \simeq 5T$ corresponding to 1.55 eV which is larger than Josephson energy. The situation is clearly critical.
3. One can ask whether also a local reduction of temperature around cell membrane in the fourth phase of water is needed.

“Electric expansion” of water giving rise to charge separation and presumably creating fourth phase of water is reported to occur [H11, H1].

- (b) Could the electric expansion/phase transition to dark phase be adiabatic involving therefore no heat transfer between the expanding water and environment? If so, it would transform some thermal energy of expanding water to work and reduce its temperature. The formula for the adiabatic expansion of ideal gas with f degrees of freedom for particle ($f = 3$ if there are no other than translational degrees of freedom) is $(T/T_0) = (V/V_0)^{-\gamma}$, $\gamma = (f + 2)/f$. This gives some idea about how large reduction of temperature might be involved. If p-adic scaling for water volume by a power of two takes place, the reduction of temperature can be quite large and it does not look realistic.
- (c) The electric expansion of water need not however involve the increase of Planck constant for water volume. Only the Planck constant for flux tubes must increase and would allow the formation of dark proton sequences and the generation of cyclotron Bose-Einstein condensates or their dark analog in which fermions (electrons in particular) effectively behave as bosons (the anti-symmetrization of wave function would occur in dark degrees of freedom corresponding to multi-sheeted covering formed in the process).

Fourth phase of water and pre-biotic life in TGD Universe

If the fourth phase of water defines pre-biotic life form then the phase transition generating fourth phase of water and its reversal are expected to be fundamental elements of the ordinary metabolism, which would have developed from the pre-biotic metabolism. The following arguments conforms with this expectation.

1. Metabolism and fourth phase of water

1. Cell interiors, in particular the interior of the inner mitochondrial membrane are negatively charged as the regions formed in Pollack's experiments. Furthermore, the citric acid cycle, (<http://tinyurl.com/y8ubjgnc>), which forms the basic element of both photosynthesis (<http://tinyurl.com/yauwzkho>) and cellular respiration (<http://tinyurl.com/ybeefxmb>), involves electron transport chain (<http://tinyurl.com/yat3m4vk>) in which electron loses gradually its energy via production of NADP and proton at given step. Protons are pumped to the other side of the membrane and generates proton gradient serving as metabolic energy storage just like battery. The interpretation for the electron transport chain in terms of Pollack's experiment would be in terms of generation of dark protons at the other side of the membrane.
2. When ATP is generated from ADP three protons per ATP flow back along the channel formed by the ATP synthase molecule (<http://tinyurl.com/yd5ndcyk>) (perhaps Josephson junction) and rotate the shaft of a "motor" acting as a catalyst generating three ATP molecules per turn by phosphorylating ADP. The TGD based interpretation is that dark protons are transformed back to ordinary ones and possible negentropic entanglement is lost.
3. ATP is generated also in glycolysis (<http://tinyurl.com/ybzgdgve>), which is ten-step process occurring in cytosol so that membrane like structure need not be involved. Glycolysis involves also generation of two NADH molecules and protons. An open question (to me) is whether the protons are transferred through an endoplasmic reticulum or from a region of ordered water (fourth phase of water) to its exterior so that it would contribute to potential gradient and could go to magnetic flux tubes as dark proton. This would be natural since glycolysis is realized for nearly all organisms and electron transport chain is preceded by glycolysis and uses as input the output of glycolysis (two pyruvate molecules (<http://tinyurl.com/y8v7aq9s>)).
4. Biopolymers - including DNA and ATP - are typically negatively charged. They could thus be surrounded by fourth phase of water and neutralizing protons would reside at the magnetic bodies. This kind of picture would conform with the idea that the fourth phase (as also magnetic body) is fractal like. In phosphorylation the metabolic energy stored to a potential difference is transferred to shorter length scales (from cell membrane scale to molecular scale).

In glycolysis (<http://tinyurl.com/ybzgdgve>) the net reaction $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2(g) + 6H_2O(l) + \text{heat}$ takes place. The Gibbs free energy change is $\Delta G = -2880$ kJ per mole of $C_6H_{12}O_6$ and is negative so that the process takes place spontaneously. Single glucose molecule is theoretized to produce $N = 38$ ATP molecules in optimal situation but there are various energy losses involved and the actual value is estimated to be 29-30. From $Joule = 6.84 \times 10^{18}$ eV and $mol = 6.02 \times 10^{23}$ and for $N = 38$ one would obtain the energy yield .86 eV per single ATP. The nominal value that I have used .5 eV. This is roughly 5 to 8 times higher than $E = ZeV, Z = 2$, which varies in the range .1-.16 eV so that the metabolic energy gain cannot be solely due to the electrostatic energy which would actually give only a small contribution.

In the thermodynamical approach to metabolism the additional contribution would be due to the difference of the chemical potential μ for cell exterior and interior, which is added to the membrane potential as effective potential energy. The discrepancy is however rather large and this forces the question the feasibility of the model. This forces to reconsider the model of osmosis in the light of Pollack's findings.

2. Pollack's findings in relation to osmosis and model for cell membrane and EEG

Osmosis (<http://tinyurl.com/yc5dbtzv>) has remained to me poorly understood phenomenon. Osmosis means that solvent molecules move through a semipermeable membrane to another side of the membrane if the concentration of solute is higher at that side. Solute can be water or more general liquid, supercritical liquid, and even gas.

Osmosis is not diffusion: it can occur also towards a higher concentration of water. Water molecules are not attracted by solute molecules. A force is required and the Wikipedia explanation is that solute molecules approaching pores from outside experience repulsion and gain momentum which is transferred to the water molecules.

The findings of Pollack inspire the question whether the formation of exclusion zone could relate to osmosis and be understood in terms of the fourth phase of water using genuine quantal description.

In the thermodynamical model for ionic concentrations one adds to the membrane resting potential a contribution from the difference of chemical potentials μ_i at the two sides of the membrane. Chemical potentials for the ions parametrize the properties of the cell membrane reducing basically to the properties of the channels and pumps (free diffusion and membrane potential do not entirely determine the outcome).

If the transfer of ions - now protons - through cell membrane is quantal process and through Josephson junctions defined by transmembrane proteins, then the thermodynamical model can at best be a phenomenological parameterization of the situation. One should find the quantum counterpart of thermodynamical description, and here the identification of quantum TGD as square root of thermodynamics in Zero Energy Ontology (ZEO) suggests itself. In this approach thermodynamical distributions are replaced by probability amplitudes at single particle level such that their moduli squared give Boltzmann weights.

1. Simplest Josephson junction model for cell membrane

The first guess is that quantum description is achieved by a generalization of the Josephson junction model allowing different values of Planck constant at magnetic flux tubes carrying dark matter.

1. Josephson junctions correspond microscopically to transmembrane proteins defining channels and pumps. In rougher description entire cell membrane is described as Josephson junction.
2. The magnetic field strength at flux tube can differ at the opposite side of the membrane and even the values of \hbar_{eff} could in principle be different. The earlier modelling attempts suggest that $\hbar_{eff}/\hbar = n = 2^k A$, where A is the atomic weight of ion, is a starting assumption deserving testing. This would mean that each ion resides at its own flux tubes.

The phase transitions changing the value of \hbar_{eff} could induce ionic flows through cell membrane, say that occurring during nerve pulse since the energy difference defining the ratio of square roots of Boltzmann weights at the two sides of the membrane would change. Also the change of the local value of the magnetic field could do the same.

Consider first the simplest model taking into account only membrane potential.

1. The simplest model for Josephson junction defined by the transmembrane protein is as a two state system (Ψ_1, Ψ_2) obeying Schrödinger equation.

$$i\hbar_1 \frac{\partial \Psi_1}{\partial t} = ZeV\Psi_1 + k_1\Psi_2 ,$$

$$i\hbar_2 \frac{\partial \Psi_2}{\partial t} = k_2\Psi_1 .$$

One can use the decomposition $\Psi_i = R_i \exp(i\Phi(t))$ to express the equations in a more concrete form. The basic condition is that the total probability defined as sum of moduli squared equals to one: $R_1^2 + R_2^2 = 1$. This is guaranteed if the hermiticity condition $k_1/\hbar_1 = \overline{k_2}/\hbar_2$ holds true. Equations reduce to those for an ordinary Josephson junction except that the frequency for the oscillating Josephson current is scaled down by $1/\hbar_{eff}$.

2. One can solve for R_2 assuming $\Phi_1 = eVt/\hbar_{eff}$. This gives

$$R_2(t) = \sin(\Phi_0) + \frac{k_1}{\hbar_1} \sin\left(\frac{eVt}{\hbar_1}\right) .$$

R_2 oscillates around $\sin(\Phi_0)$ and the concentration difference is coded by Φ_0 taking the role of chemical potential as a phenomenological parameter.

3. The counterparts of Boltzmann weights would be apart from a phase factor square roots of ordinary Boltzmann weights defined by the exponent of Coulomb energy:

$$R = \sin(\phi_0) = \exp\left(\frac{ZeV(t)}{2T}\right) .$$

Temperature would appear as a parameter in single particle wave function and the interpretation would be that thermodynamical distribution is replaced by its square root in quantum theory. In ZEO density matrix is replaced by its hermitian square root multiplied by density matrix.

2. The counterpart of chemical potential in TGD description

This model is not as such physically realistic since the counterpart of chemical potential is lacking. The most straightforward generalization of the thermodynamical model is obtained by the addition of an ion dependent chemical potential term to the membrane potential: $ZeV \rightarrow ZeV + \mu_I$. This would however require a concrete physical interpretation.

1. The most obvious possibility is that also the chemical potential actually correspond to an interaction energy - most naturally the cyclotron energy $E_c = \hbar_{eff} ZeB_{end}/m$ of ion - in this case proton - at the magnetic flux tube. Cyclotron energy is proportional to \hbar_{eff} and can be rather large as assumed in the model for the effects of ELF em fields on brain.
2. This model would predict the dependence of the effective chemical potential on the mass and charge of ion for a fixed value of on \hbar_{eff} and B_{end} . The scales of ionic chemical potential and ion concentrations would also depend on value of \hbar_{eff} .
3. The model would provide a different interpretation for the energy scale of bio-photons, which is in visible range rather than infrared as suggested by the value of membrane potential.

The earlier proposal [K54] was that cell membrane can be in near vacuum extremal configuration in which classical Z^0 field contributes to the membrane potential and gives a large contribution for ions. The problematic aspect of the model was the necessity to assume Weinberg angle in this phase to have much smaller value than usually. This difficulty could be perhaps avoided by noticing that the membrane potentials can differ for color receptors so that the earlier assignment of specific ions to color receptors could make sense for ordinary value of Weinberg angle. Second problem is that for proton the Z^0 contribution is negligible in good approximation so that this model does not explain the high value of the metabolic energy currency.

4. The simplest model the communications to magnetic body rely on Josephson radiation whose fundamental frequency f_J is at resonance identical with the cyclotron frequency $f_c(MB)$ at particular part of the flux tube of the magnetic body: $(f_c(MB) = f_J)$. $f_c(MB)$ corresponds to EEG frequency in the case of brain and biophotons are produced from dark EEG photons as ordinary photons in phase transition reducing $\hbar_{eff} = n \times h$ to h .

In the modified model the sum $f_c + f_{J,n}$ ($f_{J,n} = E_J/n \times h$) of \hbar_{eff} -independent cyclotron frequency and Josephson frequency proportional to $1/\hbar_{eff}$ equals to cyclotron frequency $f_c(MB)$ at "personal" magnetic body varying slowly along the flux tube: $f_c + f_{J,n} = f_c(MB)$. If also the variation of f_J assignable to the action potential is included, the total variation of membrane potential gives rise to a frequency band with width roughly

$$\frac{\Delta f}{f} \simeq \frac{2f_{J,n}}{f_c + f_{J,n}} = \frac{2f_{J,1}}{nf_c + f_{J,1}} .$$

If dark photons correspond to biophotons the energy of cyclotron photon is in visible and UV range one has $nf_c = E_{bio}$ and

$$\frac{\Delta f}{f} \simeq \frac{2ZeV}{E_{bio} + ZeV} \quad .$$

The prediction is scale invariant and same for all ions and also electron unless E_{bio} depends on ion. For $eV = .05$ eV, $Z = 1$, and $E_{bio} = 2$ eV ($f \simeq 5 \times 10^{14}$ Hz) one has $\Delta f/f \sim .1$ giving 10 per cent width for EEG bands assumed in the simpler model.

If this vision is on the correct track, the fundamental description of osmosis would be in terms of a phase transition to the fourth phase of water involving generation of dark matter transferred to the magnetic flux tubes. For instance, the swelling of cell by an in-flow of water in presence of higher concentration inside cell could be interpreted as a phase transition extending exclusion zone as a process accompanied by a phase transition increasing the value of h_{eff} so that the lengths of the flux tube portions inside the cell increase and the size of the exclusion zone increases. In general case the phase transitions changing h_{eff} and B_{end} by power of two factor are possible. This description should bring magnetic body as part of bio-chemistry and allow understanding of both equilibrium ion distributions, generation of nerve pulse, and basic metabolic processes leading to the generation of ATP.

One can also model sensory receptors and try to understand the maximal sensitivity of color receptors to specific wavelengths in this framework. The new degrees of freedom make this task easy if one is only interested in reproducing these frequencies. More difficult challenge is to understand the color receptors from the first principles. It is also possible to combine the new view with the assumption that sensory receptor cells are near to vacuum extremals. This would add a cyclotron contribution to the generalized Josephson frequency depending only weakly on particle and being non-vanishing also for em neutral particles.

3. Why would charge separation generate large h_{eff} ?

The basic question is whether and how the separation of electron and proton charges generates large h_{eff} ? A possible mechanism emerged from a model [K117] explaining anomalously large gravimagnetic effect claimed by Tajmar *et al* [E5, E7] to explain the well-established anomaly related to the mass of Cooper pairs in rotating super-conduction. The mass is too large by fraction of order 10^{-4} and the proposal is that gravimagnetism changes slightly the effective Thomson magnetic field associated with the rotating super-conductor leading to wrong value of Cooper pairs mass when only ordinary Thomson field is assumed to be present. The needed gravimagnetic field is however gigantic: 28 orders larger than that predicted by GRT. Gravimagnetic field is proportional h_{eff}^2 in TGD and if one uses h_{gr} for electron-Earth system one obtains correct order of magnitude.

Nottale's finding that planetary orbits seem to correspond to Bohr orbits in gravitational potential with gigantic value of gravitational Planck constant is the basic input leading to the model of gravimagnetic anomaly.

1. By Equivalence Principle h_{gr} has the general form $\hbar_{gr} = GMm/v_0$, where M and m are the interacting masses and v_0 is a parameter with dimensions of velocity. For three inner planets one has $v_0/c \simeq 2^{-11}$.
2. The notion of h_{gr} generalizes to that for other interactions. For instance, in electromagnetic case the formation of strong em fields implying charge separation leads to systems in which $h_{em} = Z_1 Z_2 e^2 / v_0$ is large. Pollack's exclusion zone and its complement define this kind of systems and is identified as prebiotic life form.
3. Since the natural expansion parameter of perturbative expansion is the $g^2/4\pi\hbar$, one can say that transition to dark matter phase make the situation perturbative. Mother Nature is theoretician friendly.

h_{em} might be large in the exclusion zones (EZ) appearing in the water bounded by gel and their variants could play central role in living matter.

1. EZ carries very large negative charge with positive charge outside the exclusion zone.
2. TGD interpretation is in terms of $H_{1.5}O$ phase of water formed when every 4: th proton is transferred to magnetic body as dark particle with large value of h_{eff} . The proposal is that primitive life form is in question.
3. The pair formed by EZ and its complement could have large value of $h_{eff} = h_{em} = Z^2 e^2 / v_0$.
4. The velocity parameter v_0 should correspond to some natural rotation velocity. What comes in mind is that complement refers to Earth and v_0 is the rotation velocity at the surface of Earth. The prediction for h_{eff} would be of order $h_{em}/h = 4\pi\alpha Z^2 \times .645 \times 10^6 \simeq 5.9 \times 10^4 Z^2$.
5. Cell membrane involves also large charge separation due to very strong electric field over the cell membrane. Also now dark phases with large h_{em} or h_{gr} could be formed.

I have proposed that metabolic machinery generates large h_{eff} phase somehow. $h_{eff} = h_{em}$ hypothesis allows to develop this hypothesis in more detail.

1. I have speculated earlier [K63] that the rotating shaft of a molecular motor associated with ATP synthase plays a key role in generating dark matter phase. What comes in mind is that charge separation takes place associating exclusion zone with the shaft and the rotational velocity v_0 of the shaft appears in the formula for h_{em} . Of course, some numerical constant not far from unity could be present. The electric field over the mitochondrial membrane generates charge separation. One can imagine several identifications for the product of charges. The charge Z associated with the complement would be naturally associated with single dark flux tube containing dark nucleon consisting of dark protons. For instance, the charge associated with the exclusion zone could be the charge of the electronic Cooper pair giving $h_{em} = 2e \times Z/v_0$.
2. The value of v_0/c is expected to be of order 10^{-14} from the angular rotation rate of ADP synthase about few hundred revolutions per second. The order of magnitude for h_{em} could be same as for h_{gr} associated with Earth-particle system.

$h_{eff}(ATPsynthase) = h_{gr}(2e, Earth)$ would make possible reconnection of electromagnetic flux tubes with gravimagnetic flux tubes [K94].

4. Which came first: metabolism or cell membrane?

One of the basic questions of biology is whether metabolism preceded basic biopolymers or vice versa. RNA world scenario assumes that RNA and perhaps also genetic code was first.

1. The above view suggests that both approaches are correct to some degree in TGD Universe. Both metabolism and genetic code realized in terms of dark proton sequences would have emerged simultaneously and bio-chemistry self-organized around them. Dark proton sequences defining analogs of amino-acid sequences could have defined analogs of protein catalysts and played a key role in the evolution of the metabolic pathways from the primitive pathways involving only the phase transition between ordinary water and fourth phase of water.
2. There is very interesting article (see <http://tinyurl.com/ycdhd4fd>) [?]eorting that complex metabolic pathways are generated spontaneously in laboratory environments mimicking hot thermal vents. Glycolysis and pentose phosphate pathway were detected. The proposal is that these pathways are catalyzed by metals rather than protein catalysts.
3. In standard biology these findings would mean that these metabolic pathways emerged before basic biopolymers and that genetic code is not needed to code for the metabolic pathways during this period. In TGD framework dark genetic code [K58, L3] would be there, and could code for the dark pathways. Dark proton strings in one-one correspondence with the amino-acid sequences could be responsible for catalysts appearing in the pathways. Only later these catalysts would have transformed to their chemical counterparts and might be accompanied by their dark templates. One cannot even exclude the possibility that the chemical realization of the DNA-amino-acid correspondence involves its dark analog in an essential manner.

4.7.3 Phase transitions generating dark phases and sensory perception

The TGD based model for biological self-organization relies on the hierarchy $h_{eff} = nh_0$ of effective Planck constants labelling dark phases of ordinary particles residing at magnetic flux quanta [L69, L73, L80] [K92, K91]. This model generalizes and suggests the replacement of non-equilibrium thermodynamics as basis of self-organization with its quantum variant based on dark matter hierarchy. The challenge is to formulate basic thermodynamical notions like work in terms TGD based quantum theory relying on zero energy ontology (ZEO) [K77].

The basic mechanism would be a phase transition creating dark matter phase as a Bose-Einstein condensate like state with particles having identical conserved quantum numbers. Conservation laws would force the ordinary matter to have opposite total charges. For instance, in the case of work one has momentum or angular momentum as a conserved charge. In the case of charge separation and high T_c superconductivity it would be em charge. Even color charges can correspond to conserved charges in TGD framework allowing scaled variants of strong interaction physics.

Basic biological functions involving the notion of work and also the formation of sensory percepts would rely on this mechanism. Also the ZEO based theory of consciousness predicting the change the arrow of time in ordinary state function [L58] reduction plays a central role and a model of nerve pulse is discussed as an example.

Sensory perception (time reversal of motor action [L76]) could involve generation of coherent phases of dark matter carrying collective quantum numbers in 1-1 corresponds with the sensory qualia. This would represent a general charge separation process.

Consider first sensory capacitor model for color qualia [K54].

1. The notion of QCD color as analog of ordinary visual colors was originally introduced as a joke since the algebra of color summation resembles that for the summation of QCD colors in tensor product. In TGD however the dark hierarchy (h_{eff}) and p-adic length scale hierarchy predict that scaled variants of QCD type physics are possible for arbitrarily large length scales. In cellular scales scaled up QCDs are predicted. In the length scale range between cell membrane thickness and nucleus size there are as many as 4 Gaussian Mersennes, which is a number theoretical miracle. They could label copies of QCDs with size scale for the analogs of hadrons given by the corresponding p-adic length scales. QCD type colors could correspond to perceived colors [K54] [L66].
2. Gluons or quarks labelled by color charge characterizing particular color quale would flow between the plates of "capacitor" associated with the sensory receptor. The amount of particular color charge increases at the other plate giving rise to sensation of this particular color quale and its complement at the other plate - by color confinement also the same plate could also contain regions with complementary colors. This would explain why we see around a region of particular color a narrow boundary with complementary color.
3. The model for sensory perception as sequences of analogs of weak measurements suggest that the flow of color charges could induce color qualia. The prediction emerging from the structure of $SU(3)$ color algebra would be four pairs of basic color and complement color: 3 ordinary pairs and white-black pair. They could correspond to particular changes of color quantum numbers and color quantum numbers of gluons. Also color mixing could be understood.
4. Photons are not coloured but gluons (and also quarks) are, and the latter and could be responsible for color sensation. How photon flux can generate a flow of color quantum numbers? The notion of induced gauge field -classical color gauge potentials would be projections of $SU(3)$ Killing vectors - explains this.

In TGD classical em field is sum of two terms induced Kähler form and neutral vectorial component of spinor curvature [K19]. Classical gluon field has components proportional to classical color Hamiltonian (function in CP_2 which can be said to have quantum numbers of gluon) and induced Kähler form. In general case any classical em field is accompanied by a classical color field.

Photons are accompanied by classical em fields and therefore also by classical gluon fields at the fundamental level: this correspondence disappears at QFT limit unable to describe biology and sensory experience. The flow of photons to retina would be accompanied by classical em and color fields and therefore a flow of gluons. Also quark flow between the plates of sensory capacitor could generate the color qualia.

5. A simple model for the visual qualia is in terms of a phase transition transforming gluons of a scaled copy of QCD to ordinary gluons. Dark gluons would form a BE condensate and force a formation its shadow at the level of ordinary matter. This is a variant of sensory receptor as quantum capacitor. The plates of capacitor correspond to dark and ordinary phase and the analog of electric breakdown means formation of the dark phase. Cooper pairs of quarks with quantum numbers of gluon would be second option but gluons in TGD framework are actually this kind of pairs!!

4.8 Some objections against TGD view of qualia

I have considered the problem of qualia several times and have proposed several models for qualia [K54] [L87]. I have not been quite happy with the details of the original proposal. A lot of progress in the understanding of TGD has taken place since I considered qualia from the TGD point of view for the first time, and it is appropriate to take a new look at the situation.

4.8.1 Recalling the general ideas about qualia

The obvious idea is that qualia can be assigned with a state function reduction (SFR) as measurement of observables [K54].

1. The first class of basic qualia would correspond to infinitesimal generators of the fundamental symmetries. Spin, color and electroweak quantum numbers would represent fundamental qualia. Supersymplectic group for the product of light-cone boundary and CP_2 would act as isometries of the "world of classical worlds" and this would give rise to dynamical symmetry groups [K102] and corresponding qualia.

Momentum and position are certainly fundamental observables. $M^8 - H$ duality [L90, L91] has an interpretation as a generalization of momentum position duality of wave mechanics forced by the replaced of point like-particle with 3-surface whose orbit defines space-time surface as analog of Bohr orbit realizing holography forced by 4-D general coordinate invariance.

At the level of M^8 momentum eigenstates correspond to states for which mass shells are determined by the roots of the polynomial defining 4-D surface of M^8 by holography. This surface is mapped by $M^8 - H$ duality to a space-time surface in H as a minimal surface with singularities in H [L122, L123].

Measurement of momentum produces a state localized to a set of points of mass shells of M^8 corresponding to quark momenta. The measurement of position as a dual variable for momentum gives rise to a superposition of this kind of states with coefficients $\exp(ip \cdot m)$ mapped by $M^8 - H$ duality to a state within a single causal diamond (CD) H localized to the point. These two state bases correspond to H -picture and M^8 picture.

Twistor lift of TGD generalizes this duality also to the spin and electroweak spin and one can say that spin 1/2 state with a given quantization axis corresponds in M^8 to either point defined by the discrete direction of quantization axes at unit sphere. In the twistor space of H it corresponds to a wave function at the twistor sphere CP_1 .

2. There would also be geometric qualia related to the shape and size of objects. The flag manifolds defined by Cartan groups of symmetry groups and having interpretation as a space for the choices of quantization axes would represent example of geometric qualia, which I have called flag manifold qualia [K54] [L66]. The flag manifold $SU(3)/U(1) \times U(1)$ for color group defines twistor space for CP_2 and the model for honeybee dance involves this space as discovered by topologist Barbara Shipman [A6].

The twistor space CP_3 for Minkowski space has interpretation as a choice of the origin of Minkowski coordinate and spin quantization axis. Points of M^4 separated by light-like distance would be equivalent. The product of these twistor spaces appears in the twistor lift of TGD [K129, L57] [L122, L123]. The space of the quantization axis for weak isospin corresponds to a sphere but the breaking of weak isospin symmetry at the level of geometry of CP_2 could fix the quantization axis.

3. What about qualia such as acceleration? Acceleration corresponds to the rate of change for momentum. Momentum is a relative notion by Lorentz invariance and always relative to some system. This requires two systems. I have proposed that the relative motion of the magnetic body and biological body is behind the experience of acceleration that is force.

In wave mechanics, force would be represented as a commutator of the Hamiltonian of the system representing the magnetic body (MB) and biological body with the momentum related to relative motion. The measurement would give an eigenstate of this operator with a constant force. If the scaling for the entire system determines the analog of the time evolution, one should decompose this scaling to single particle operators associated with the magnetic and biological body and the part representing the force when time evolution corresponds to scaling instead of translation. Eigenstates of this term would result in the measurement of force.

The basic objection against the identification of state function reduction as a moment of consciousness is that sensory mental images have a finite duration.

One can imagine two ways of identifying qualia: as an outcome of quantum measurement or in terms of a change/transfer of quantum numbers. Both the resolution of the objection and the two alternative identifications of qualia will be discussed in the context provided by the recent view of TGD. For definiteness, the discussion will be restricted to color qualia since it provides an opportunity to discuss how the new physics predicted by TGD would be involved with qualia.

4.8.2 How can the perception of quale have a finite duration?

There is a philosophical problem related to the fact that the experience of, say, color has a duration. One could argue that the idea that color sensations correspond to SFRs, that is, a single moment of consciousness, is not consistent with this. One can imagine two ways to overcome this objection.

First option

One could argue as follows.

1. It is not possible to experience that one is not conscious so that the illusion of finite duration of sensory quale is created.
2. The "small" SFR as the TGD counterpart of a weak measurement in quantum measurement theory based on zero energy ontology (ZEO) begins as a cognitive measurement cascade in a Galois group of extension of rationals associated with a rational polynomial defining a given space-time region [L98, L124].

This cascade corresponds to a decomposition of the representation of Galois group for a functional composite polynomial $P_1 \circ \dots \circ P_n$ for which Galois group of the algebraic extension has decomposition to a semidirect product of relative Galois groups G_i associated with pairs P_i, P_{i+1} . This yields a product of irreps of G_i .

3. The cognitive cascade as a quantum correlate of analysis, is followed by measurements in quark spin and momentum degrees of freedom for the quark states defining the irreps of G_i . One can argue that the duration of the qualia mental image corresponds to the geometric lifetime of this sequence since eventually a BSFR, which means the death of the qualia mental image occurs. By the above argument, the steps in this sequence would not be experienced separately.

4. There is an objection against this view. ZEO [L89, L112] motivates the proposal is that we are during sleep living in an opposite direction of time and *classically* it is impossible to receive signals from that period since the signals travel in an opposite time direction (TGD predicts that also signals with "wrong" time direction can be received and sent but are rare and the process involves BSFR at the level of system representing mental images as subself). However, when we wake up in the morning, we remember that we were conscious yesterday and realize that we do not remember anything about the period of sleep. Could the same argument apply to mental images related to qualia?

Second option

One could also argue as follows.

1. State function reductions (SFRs) (actually "small" SFRs responsible for the "flow of consciousness") *initiate* a conscious experience of say some quale realized as subself, mental image. The next "small" SFR would end this experience and initiate a new one. If SFR is "big", the mental image dies and reincarnates with the opposite arrow of time and experience disappears from the consciousness of self.

Mathematicians would say that a delta function is replaced with a step function as far as interpretation is considered. Nothing at the level of mathematical formalism has changed.

The structure of conscious experiences reflects the structure of the physical states. In this spirit, one could argue that SFRs serve as a holographic data at the ends of the duration of the conscious experience, which determine the conscious experience associated with the duration itself. One would have have holography of consciousness.

2. Is this interpretation consistent with the fact that change is necessary for qualia as already basic physiological facts show? For instance, if the saccadic motion of the eye is prevented, the perceptive field becomes dark first and after that the visual consciousness disappears. This finding can be consistent with the new view since the lifetimes of the qualia mental images as subselves are certainly finite.

Critical reader could ask whether the two options are only slightly different verbalizations of the same basic intuition and perhaps regard the latter verbalization as mathematically clearer. The latter option looks clearer than the first one although it does not literally conform with what I have been telling for three decades about SFRs as basic building bricks of conscious experience! It can take decades to express really clearly what you have understood!

4.8.3 Two alternative identifications of qualia

One can consider two alternative identifications of qualia: as an outcome of quantum measurement or as a change/transfer of quantum numbers.

Quale as an outcome for a measurement of quantum numbers?

Quantum measurement theory suggests the identification of qualia as resulting in quantum measurement and therefore labelled by eigenvalues of the measured observables. Qualia would therefore characterize the quantum state emerging in SFR (most naturally SSFR) and one might say that qualia are determined by the properties of the state.

How does this relate to the long held TGD based view that since SFRs are the basic building bricks of conscious experience, conscious experience cannot be regarded as a property of a physical state as physicalists argue. Hence "consciousness" is a misleading term. Holography of consciousness suggests the interpretation that conscious experience and qualia are about the properties of the state emerging in SFR but are not its properties.

There is a finite classical non-determinism associated with the space-times surfaces as analogs of 4-D soap films. A possible interpretation is as a correlate for the intentional component of the conscious experience. This would fit with the vision that life and intentionality, which is essential for life, emerge at quantum criticality. SSFRs would be behind sensory experience and classical non-determinism behind the intentional component of the experience.

Consider color vision as an example.

1. Sensory receptors (such as the eye) could be seen in this framework as a collection of subsystems (rods and cones), which together form a quantum coherent state. SFR would produce a collection of different outcomes and the experienced quale would be a statistical average of the outcomes. In the ensemble interpretation, the probabilities of various quantum number combinations (basic colors) would be given by the reduction probabilities. This explains color summation. In holography with a slight failure of determinism, one cannot exclude temporal averages.
2. "Color symmetry" was originally a joke inspired by the algebraic correspondence with visual colors. The proposal was that visual colors could correspond to quark colors. Perception would be measurement of color quantum numbers. This would predict 3 colors for quarks and 3 complementary colors for antiquarks. White and black are also considered as colors.
3. This sounds outlandish but makes sense in the TGD framework, where quarks are the only fundamental fermions in the recent formulation of TGD. Moreover, TGD predicts a hierarchy of effective Planck constants $\hbar_{eff} = n\hbar_0$, where n has a number theoretic interpretation as dimension of an extension of rationals associated with a polynomial defining a space-time region considered. n measures the algebraic complexity and serves as a kind of IQ.

$\hbar_{eff} = n\hbar_0$ labels phases of ordinary matter and these phases behave like dark matter relative to each other. Field bodies carry these phases and magnetic bodies MBs with various values of \hbar_{eff} can act as "bosses" controlling lower levels, in particular the ordinary matter at the bottom of the master-slave hierarchy.

4. Compton lengths are scaled up by n and MBs can carry dark quarks and gluons even in cellular length scales. Below the confinement scale which is the natural scale now quarks and gluons are effectively massless. One could say that we directly see quarks!

This is true also for the weak interactions and the presence of dark weak variants of weak bosons at magnetic body (MB) could explain the chiral selection in living matter, which is very difficult to understand in the standard model because the violation of parity in weak interactions is extremely small above Compton length of weak bosons. In living matter the Compton length would scale up at MBs and MBs acting as "bosses" would induce large parity violation even in cell scale.

Quale as a change of quantum numbers?

An alternative option has been that the classical flows of color quantum numbers could correspond to qualia. This led to the sensory capacitor model of cell membrane [K54, K91].

1. Since the changes for quark quantum numbers correspond to gluons, there would be 3+3 colors corresponding to color charged gluons. Classically one could think that the flow of color quantum numbers between two subsystems in a sensory receptor could give rise to an experience of quale such as color. This led to the sensory capacitor model of cell membrane [K54, K91].
2. At elementary particle level, the change of color quantum numbers for a single particle could be induced by an exchange of a gluon between quarks. But can one associate this flow with a quantum measurement of something? For quantum groups and Yangians the color charge operators are sums of single particle contributions and many particle contributions. Two-quark contributions would make possible opposite change of color quantum numbers for the members of a quark pair. Could the measurement of the quantum group counterpart of color charge give rise to this kind of change? The first option is the simpler and more natural one.
3. In the sensory capacitor model, one could model the situation as a pair of harmonic oscillator wells representing the plates of a capacitor characterized by Hamiltonian $H = H_0 + V$. The presence of the capacitor plates would be described by a sum $H_0 = -\hbar^2 \partial_x^2 / 2m + kx^2/2 + k(x-d)^2/2$ of harmonic oscillator Hamiltonians describing a double potential well. The potential driving the particles between the plates would be described by $V = -qEx$.

The commutator $[H, V] = \hbar^2 \partial_x E / m = i \hbar E p$, $p = i \hbar \partial_x / m$ and non-hermitian in plane wave basis at the limit of infinite distance between the plates.

4. p is a linear combination of creation and annihilation operator for the harmonic oscillator quanta and one can ask whether the analogs of eigenstates of p correspond to coherent states for the annihilation operator having in general complex eigenvalues. Instead of eigenstate, a coherent state for the negative energy part of force could be created at the plate which contains the particle in the initial state. The coherent state would be a harmonic oscillator state for which the origin would be shifted along the line connecting the plates. The probabilities for eigenstates would be given by the overlap of the coherent states as Gaussian with the original ground state or excited state at either plate.
5. A more realistic formulation could be as a quantum phase transition for a cyclotron condensate of quarks and antiquarks assignable to the opposite layers of the sensory capacitor carrying opposite color charges. This phase transition is analogous to a spontaneous magnetization, or rather its reversal, and would emit a burst of gluons changing the quantum numbers of cyclotron condensates at the layers.

The TGD view about dark matter leads to the notion of dark N-particle as an analog of a Bose-Einstein condensate. A dark N gluon would be emitted.

The description of the dynamics of this transition could involve the bilinear coupling of classical induced color field components $G_{\alpha\beta}^A = H_A J_{\alpha\beta}$ proportional Kähler form and Hamiltonians of color isometries with gluon field, and associated with a "massless" extremal (ME) connecting the plates. ME or MEs would serve as a classical space-time correlate for a mode of a generic radiation field with a fixed polarization and direction of propagation.

4.8.4 Zero energy ontology, holography = holomorphy vision and TGD view of qualia

Zero energy ontology (ZEO) and holography = holomorphy vision providing an exact solution of classical field equations allow to solve some earlier problems of TGD inspired theory of consciousness and to sharpen earlier interpretations. Holography = holomorphy vision generalizes 2-D conformal invariance to 4-D situation and provides a universal solution of field equations in terms of minimal surfaces defined as roots for pairs of generalized analytic functions of the generalized complex coordinates of $H = M^4 \times CP_2$ (one of the coordinates is hypercomplex coordinate with light-like coordinate curves) [L149, L162].

Consider first the implications of ZEO [L89] [K146].

1. ZEO predicts that in "big" state function reductions (BSFRs) as counterparts of ordinary SFRs the arrow of time changes. "Small" SFRs (SSFRs) are the counterpart for repeated measurements of the same observables, which in standard QM leave the system unaffected (Zeno effect). In SSFRs, the state of the system however changes but the arrow of time is preserved. This has profound implications for the understanding of basic facts about consciousness.
2. The sequence of SSFR corresponds to a sequence of delocalizations in the finite-dimensional space of causal diamonds $CD = cd \times CP_2$ [L155] and consists of delocalizations (dispersion) followed by localizations as analogs of position measurements in the moduli parameterizing the CD. This sequence gives rise to subjective existence, self.
3. BSFR has interpretation is accompanied by reincarnation with an opposite arrow of geometric time. BSFR means the death of self as a sequence of "small" SFRs (SSFRs) and corresponds to falling asleep or even death. Death is therefore a completely universal phenomenon. The next BSFR means birth with the original arrow of time: it can be wake-up in the next morning or reincarnation taking place considerably later, life time is the first guess for the time scale. This follows from the fact that causal diamond $CD = cd \times CP_2$ increases in size during the sequence of SSFRs.

4. What forces the ZEO is holography which is slightly non-deterministic due to the classical non-determinism of an already 2-D minimal surface realized as a soap film for which the frame spanning it does not fix it uniquely. This means that the 4-D space-time surface located inside CD and identifiable as the analog of Bohr orbit determined by holography must be taken as a basic object instead of a 3-surface. In SSFRs, the state at the passive light-like boundary of CD is unaffected just as in Zeno effect but the state at the active boundary changes. Due to the dispersion in the space of CDs the size of CD increases in statistical sense and the geometric time identifiable as the distance between the tips of CD increases and correlates with the subjective time identifiable as sequence of SSFRs.
5. In standard quantum theory, the association of conscious experience with SFRs does not allow us to understand conscious memories since the final state of state function reduction does not contain any information about the earlier states and state function reductions. Zero energy ontology leads to a concrete view of how conscious memories can be realized in the TGD Universe [L164]. The superposition of space-time surfaces between fixed initial state and changing final state of SSFR contains the classical information about previous states and state function reductions and makes memory possible. The slight non-determinism of the classical time evolution implies loci of non-determinism as analogs of soap film frames and memory recall corresponds to a quantum measurement at these memory seats.
6. SSFRs correspond to repeated measurements of the same observable and the eigenvalues of the measured observables characterize the conscious experience, "qualia", partially. Also new commuting observables related to the non-determinism can appear and the set of observables can be also reduced in size. The superposition of the space-time surfaces as analogs of non-deterministic Bohr orbits however changes in the sequence of SSFRs and the associated classical information changes and can give rise to conscious experiences perhaps involving also the qualia remaining constant as long as self exists.

The eigenvalues associated with the repeatedly measured observables do not change during the sequence of SSFRs and one can ask if they can give rise to a conscious experience, which should be assignable to change. Could these constant qualia be experienced by a higher level self experiencing self as sub-self defining a mental image? This higher level self would indeed experience the birth and death of subself and therefore its qualia.

The observables at the passive boundary of CD correspond qualia of higher level self and the additional observables associated with SSFRs correspond to those of self. They would be associated with self measurements.

7. Note that self dies when the measured observables do not commute with those which are diagonalized at the passive boundary. It is quite possible that these kinds of temporary deaths take place all the time. This would allow learning by trial and error making possible conscious intelligence and problem solving since the algebraic complexity is bound to increase: this is formulated in terms of Negentropy Maximization Principle [L150].

ZEO and holography = holomorphy vision allow us to understand some earlier problems of TGD inspired theory of consciousness and also to sharpen the existing views.

Two models for how sensory qualia emerge

Concerning sensory qualia [K54] I have considered two basic views.

1. The first view is that the sensory perception corresponds to quantum measurements of some observables. Qualia are labelled by the measured quantum numbers.
2. The second, physically motivated, view has been that qualia correspond to increments of quantum numbers in SFR [K54]. This view can be criticized since the quantum numbers need not be well-defined for the initial state of the SFR. One can however modify this view: perhaps the redistribution of quantum numbers leaving the total quantum numbers unaffected, is what gives rise to the sensory qualia.

The proposed physical realization is based on the sensory capacitor model of qualia. Sensory receptors would be analogous to capacitors and sensory perception would correspond to dielectric breakdown. Sensory qualia would correspond to the increments of quantum numbers assignable to either cell membrane in the generalized di-electric breakdown. The total charges of the sensory capacitor would vanish but they would be redistributed so that both membranes would have a vanishing charge. Membranes could be also replaced with cell exterior and interior or with cell membrane and its magnetic body. Essential would be emergence or disappearance of the charge separation.

This picture conforms with the recent view about the role of electric and gravitational quantum coherence assignable to charged and massive systems. In particular, electric Planck constant would be very large for charged systems like cell, neuron, and DNA and in the dielectric breakdown and its time reversal its value would change dramatically. If this is the case the dynamic character of effective Planck constant involving phase transition of ordinary to dark matter and vice versa would be essential for understanding qualia.

3. As the above argument demonstrated, the qualia can be decomposed to internal and external qualia. The internal qualia correspond to self-measurements of sub-self occurring in SSFRs whereas the external qualia correspond to the qualia measured by self having sub-self as a mental image. They are not affected during the life-time of the mental image. Whether the self can experience the internal qualia of subself is far from clear. The sensory capacitor model would suggest that this is the case. Also the model for conscious memories suggests the same. The internal qualia would correlate with the classical dynamics for the space-time surfaces appearing in the superposition defining the zero energy state and make possible, not only conscious memory and memory recall based on the failure of precise classical determinism, but also sensory qualia as subelves experienced as sensory mental images.

Geometric and flag manifold qualia and the model for the honeybee dance

One can decompose qualia to the qualia corresponding to the measurement of discrete observables like spin and to what might be called geometric qualia corresponding to a measurement of continuous observables like position and momentum. Finite measurement resolution however makes these observables discrete and is realized in the TGD framework in terms of unique number theoretic discretization of the space-time surface.

Especially interesting qualia assignable to twistor spaces of M^4 and CP_2 .

1. Since these twistor spaces are flag manifolds, I have talked about flag-manifold qualia. Their measurement corresponds to a position measurement in the space of quantization axes for certain quantum numbers. For angular momentum this space would be $S^2 = SO(3)/SO(2)$ and the localization S^2 would correspond to a selection of the quantization axis of spin. For $CP_2 = SU(3)U(2)$ the space of the quantization axis for color charges corresponds to 6-D $SU(3)(U(1) \times U(1))$, which is identifiable as a twistor space of CP_2 .
2. The twistor space of M^4 can be identified locally as $M^4 \times S^2$, where S^2 is the space of light-like rays from a point of M^4 . This space however has a non-trivial bundle structure since for two points of M^4 connected by a light-like ray, the fibers intersect.

What is the corresponding flag manifold for M^4 ?

1. The counterpart of the twistor sphere would be $SO(1,3)/ISO(2)$, where $ISO(2)$ is the isotropy group of massless momentum identifiable as a semidirect product of rotations and translations of 2-D plane. $SO(1,3)/ISO(2)$ corresponds to the 3-D light-cone boundary (other boundary of CD) rather than S^2 since it has one additional light-like degree of freedom. Is the twistor space as a flag manifold of the Poincare group locally $M^4 \times SO(1,3)/ISO(2)$. This is topologically 7-D but metrically 6-D. Since light rays are parametrized by S^2 one can also consider the possibility of replacing $M^4 \times SO(1,3)/ISO(2)$ with S^2 in which case the twistor space would be 6-D and represented a non-trivial bundle structure.
2. Could one restrict M^4 to E^3 or to hyperbolic 3-sphere H^3 for which light-cone proper time is constant? In these cases the bundle structure would trivialize. What about the restriction of

M^4 to the light-like boundaries of CD ? The restriction to a single boundary gives non-trivial bundle structure but seems otherwise trivial. What about the union of the future and past boundaries of CD ? The bundle structure would be non-trivial at both boundaries and there would also be light-like rays connecting future and past light-like boundaries.

The unions $\cup_i H_i^3(a_i)$ of hyperbolic 3-spaces corresponding different values $a = a_i$ of the light-cone proper time a emerge naturally in $M^8 - H$ duality and could contain the loci of the singularities of space-time surfaces as analogs of frames of soap films. Also these would give rise to a non-trivial bundle structure.

These identifications differ from the usual identification of the M^4 twistor space as CP_3 : note that this identification of the M^4 twistor space is problematic since it involves compactification of M^4 not consistent with the Minkowski metric. Holography = holomorphy vision in its recent form involves a general solution ansatz in terms of roots of two analytic functions f_1 and f_2 and $f_2 = 0$ [L162], which identifies the twistor spheres of the twistor spaces of M^4 and CP_2 represented as metrically 6-D complex surfaces of H . M^4 twistor sphere corresponds to the light-cone boundary in this identification. This identification map also defines cosmological constant as a scale dependent dynamical parameter.

A basic application for the twistor space of CP_2 has been in the TGD based model [K54, K42] for the findings of topologist Barbara Shipman [A6, A7, A8, A9, A5], who made the surprising finding that the twistor space of CP_2 , naturally assignable to quarks and color interactions, emerges in the model for the dance of honeybee. This kind of proposal is nonsensical in the standard physics framework but the predicted hierarchy of Planck constants and p-adic length scales make possible scaled variants of both color and electroweak interactions and there is a lot of empirical hints for the existence of this hierarchy, in particular for the existence as a scaled up variants of hadron physics leading to a rather radical proposal for the physics of the Sun [L165].

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Shipman found that the honeybee dance represents position in $SU(3)/U(1) \times U(1)$ coding for the direction and distance of the food source in 2-D plane! Why should this be the case? The explanation could be that the space-time surfaces as intersections of 6-D counterparts of the twistor spaces $ISO(2) \times \cup_i H^3(a = a_i)$ resp. $SU(3)/U(1) \times U(1)$ identified as a root of analytic function f_1 resp. f_2 [L162] have space-time surface as 4-D intersection so that honeybee dance would map the point of the flag manifold $SU(3)/U(1) \times U(1)$ to a point of $M^4 \times S^2$ or $\cup_i H^3(a = a_i) \times ISO(2)$ (locally). The restriction to a 2-D subset of points could be due to the measurement of the distance of the food source represented by the point of H_i^3 (or M^4).

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Chapter 5

About the Nature of Time

5.1 Introduction

The notion of time remains one of the most problematic concepts of physics. In classical physics the different properties of the time of Newton's equations and thermodynamical time are puzzling. In special relativity and general relativity the notion of simultaneity becomes a problematic concept and challenges the naive Newtonian view about time flow as a motion of 3-D time=constant snapshot of 4-D space-time. The replacement of time=constant 3-surface with past directed light-cone assignable to the world-line of observer resolves this problem. In general relativity the problem is that past light-cones need make sense only locally. In quantum measurement theory the localization of the state function reduction process into a finite space-time volume is in conflict with the determinism of Schrödinger equation. In biology the presence of self-organization processes like self assembly challenge second law of thermodynamics in short time scales. In neuroscience the finding of Libet suggesting that neural activity seems to precede conscious decision forces to give up the notion of free will or the naive identification of experienced and geometrical time.

In this chapter I will consider a new view about time based on Topological Geometro-dynamics [K138], which can be regarded as an attempt to unify fundamental interactions assuming that space-times are representable as 4-dimensional surfaces of certain higher-dimensional space-time $H = M^4 \times CP_2$ (M^4 denotes 4-D Minkowski space and CP_2 complex projective space of 2 complex dimensions) fixed by the requirement that the theory explains standard model symmetries and provides a geometrization of classical gauge fields and gravitational fields.

The construction of quantum TGD leads to a radical revision of space-time concept (many-sheeted space-time and topological field quantization), and forces also to generalize the original view about embedding space. p-Adic physics as physics of cognition is part of TGD inspired theory of consciousness and the need to fuse real and p-adic physics to single coherent whole forces to revise the notions of number and space-time: the outcome seems to be what one could call adelic space-time [K136]. Reals and p-adic number fields together with their extensions are glued together to form a larger structure and same applies to space-time and embedding space. It has been also necessary to replace the standard positive energy ontology with what I call zero energy ontology. These generalizations are of special importance in TGD inspired theory of consciousness and of quantum biology.

There are several first principle approaches to quantum TGD and following gives only a very concise summary of them.

1. Generalization of Einstein's program of geometrizing classical physics so that quantum theory can be seen as a theory of *classical* spinor fields in the world of classical worlds (WCW) consisting of light-like 3-surfaces and possessing Kähler geometry [K32, K142]. By general coordinate invariance (GCI) classical physics becomes an exact part of quantum theory in a well-defined sense. A geometrization of Fermi statistics is obtained, and the Clifford algebra associated with the spinors of WCW can be regarded as a direct sum of von Neumann algebras known as hyper-finite factors of type II_1 (HFFs) closely related to quantum groups and non-commutative geometry.

2. Quantum TGD as almost topological field theory (TQFT) with fundamental objects identified as light-like 3-surfaces and having generalized super-conformal symmetries as symmetries [K31, K30] : the notion of braid is the basic building block of this approach.
3. There are two kinds of conformal symmetries corresponding to the boundary of light-cone of Minkowski space and light-like 3-surfaces, and these symmetries alone dictate to high degree the physics. Quite recently it turned that also a symplectic analog of conformal field theory emerges naturally in TGD framework (super-symplectic symmetries) and this led to a concrete proposal for how to construct n-point functions needed to calculate M-matrix [K129].
There are two new elements [K129]. The first one is the generalization of twistors from 4-dimensional to 8-dimensional context made possible by the octonion structure of embedding space. $H = M^4 \times CP_2$ has completely unique twistorial properties. Second new element is actually a revival of the old idea that scattering amplitudes are representations for sequences of algebraic operations - product and co-product defining fundamental 3-vertices - connecting two sets of algebraic objects. The algebraic objects are elements of the Yangian associated with super-symplectic algebra realizes as Noether charges assignable to strings connecting partonic 2-surfaces. Universe would be performing quantum algebraic manipulations.
4. Physics as a generalized number theory involves three different threads corresponding to need fuse real and various p-adic physics to single coherent whole by using a generalization of number concept obtained by gluing reals and various p-adic number fields and their extensions together along rationals and common algebraics [K120] ; the observation that standard model symmetries and dynamics of quantum and classical TGD are to high degree dictated by classical number fields [K123] ; and the ideas inspired by the notion of infinite prime [K119].
5. The identification of WCW Clifford algebra elements as hyper-octonion (subspace of complexified octonions spanned by real unit and octonionic imaginary units multiplied by the commuting additional imaginary unit) valued conformal fields having values in HFF provides a justification for the concept of number theoretic braid needed both in the fusion of real and p-adic physics and in TGD as almost TQFT approach.

What number theoretic braid is has remained unclear. Now it is however clear that string world sheets belong in a well-defined sense to the intersection of reality and various p-adicities defining adelic embedding space and space-time as its surface. Number theoretic braids identified as boundaries of string world sheets would be very simple: they would consist of segments which are light-like geodesics of embedding space. Whether they can be braided without consisting of this kind of pieces remains unclear.

Discretization is not so simple as one might think: the problem is that standard discretization defines only 0-dimensional objects consisting of points. What I call co-dimension two rule tells how the discretization is achieved for higher-dimensional objects. Partonic 2-surfaces are mapped to a discrete set of points- the ends of string boundaries carrying fermion number, their 3-D light-like orbits are replaced with the boundaries of string world sheets whose defining parameters are algebraic numbers, space-time surfaces in turn are replaced by string world sheets whose parameters are again algebraic numbers. Thus discretizations defined abstraction hierarchy. This brings in mind category theoretical construct of n-objects with $n = 1, 2, 3$ giving three hierarchy levels. Remarkably the hierarchy ends at the third step and string world sheets are the highest dimensional objects that can reside in the intersection of realities and p-adicities.

6. The hierarchy of Planck constants $\hbar_{eff}/\hbar = n$ realizing quantum criticality [K47] in terms of infinite number dark matter phases suggests a generalization of the notion of embedding space by replacing it with a book like structure having as its pages singular coverings and factor spaces of H and allowing to realize geometric correlates for the choice of quantization axis in quantum measurement: the particles at different pages of this book are “relatively dark” since they do not possess local interaction vertices which means a radically new way to interpret dark matter. It has turned out that this generalization is only an auxiliary tool. The proper notion is space-time surface with a structure of n-dimensional covering and the sheets of covering are due to the non-determinism of Kähler action. There are n

conformal equivalence classes of space-time surfaces connecting the space-like surfaces at opposite boundaries of causal diamond (CD). One allows not only space-time surface with one such sheet but also those consisting of several sheets and this should lead to charge fractionization.

There is infinite fractal hierarchy of breakings of super-symplectic symmetry having structure of conformal symmetry: the elements of the sub-algebra have conformal weights are n -ples of those for the full algebra act as gauge symmetries so that it is isomorphic to the entire algebra. There is infinite number of inclusion series for these algebras such that n_i divides n_{i+1} and they correspond to reduction of criticality. Therefore TGD Universe is like a hill at the top of hill at the top of hill.... The phase transitions increasing h_{eff} and generating dark matter occur spontaneously. Living systems however tend to stay at criticality defined by particular h_{eff} and the phase transition changing it can be said to mean death of self and its re-incarnation at opposite boundary of CD. In the phase transition some gauge degrees of freedom transform to physical ones. The interpretation is as improvement of measurement resolution. Basically this measurement resolution is cognitive and derives from number theoretic constraints and reflects the character of algebraic extension of p-adic numbers.

7. Zero energy ontology and the notion of finite measurement resolution formulated in terms of inclusions of HFFs fix quantum dynamics highly in terms of Connes tensor product allowing to interpret quantum theory as a square root of thermodynamics [K138, K30]: finite measurement resolution has number theoretic braid as its space-time correlate so that various approaches to TGD are closely related. The hierarchies of super-symplectic symmetry breakings define hierarchies of inclusions for HFFs.
8. Quantum theory of consciousness as a generalization of quantum measurement theory to include observer to the theory [L10].

The article series about TGD and its applications to biology and consciousness [?, K132], [L10, L8, L5, L7, L6, L4] gives an overall view about quantum TGD. In the following I will concentrate only on the aspects of quantum TGD relevant for the notion of time. I will first describe zero energy ontology and p-adicization program and after that consider the problem of time.

The TGD based vision about how the arrow of geometric time is by no means fully developed and final. I will describe also the approaches which look now partially wrong.

1. What seems clear now is the decisive role of ZEO and hierarchy of CDs, and the fact that the quantum arrow of geometric time is coded into the structure of zero energy states to a high extent. The still questionable but attractively simple hypothesis is that U matrix connects two basis with opposite quantum arrows of geometric time: is this assumption really consistent with what we know about the arrow of time? If this is the case, the question is how the relatively well-defined quantum arrow of geometric time implies the experienced arrow of geometric time. Should one assume the arrow of geometric time separately as a basic property of the state function reduction cascade or more economically- does it follow from the arrow of time for zero energy states?
2. The first idea was that state function reductions occur alternately at the two boundaries of CD. If the reduction occurs at given boundary is immediately followed by a reduction at the opposite boundary, the arrow of time alternates: this does not conform with intuitive expectations: for instance, this would imply that there are two selves assignable to the opposite boundaries!
3. Zero energy states are however de-localized in the moduli space CDs (size of CD plus discrete subgroup of Lorentz group defining boosts of CD leaving second tip invariant). One has quantum superposition of CDs with difference scales but with fixed upper or lower boundary belonging to the same light-cone boundary after state function reduction.

In standard quantum measurement theory the repetition of state function reduction does not change the state but now it would give rise to the experienced flow of time. Zeno effect indeed requires that state function reductions can occur repeatedly at the same boundary.

In these reductions the wave function in moduli degrees of freedom of CD changes. This implies “dispersion” in the moduli space of CDs experienced as flow of time with definite arrow. This view lead to a precise definition of self as sequence of quantum jumps to the reducing to the same boundary of CD.

Each reduction leaves the passive boundary of CD invariance and also the part of zero energy state associated with it but can induce localization to single CD. The reduction must have some effect on state and it might be that the localization is this effect.

4. This approach codes also the arrow of time at the space-time level: the average space-time sheet in quantum superposition increases in size as the average position of the “upper boundaries” of CDs drift towards future state function reduction by state function reduction.
5. In principle the arrow of time can temporarily change and probably takes place in elementary particle scales and living matter routinely. Phase conjugate laser beam is a non-biological example about reversal of the arrow of time. The act of volition would correspond to the first state function reduction to the opposite boundary so that the reversal of time arrow at some level of the hierarchy of selves would take place in the act of volition.

This vision involves minimal number of assumption and is the most convincing one found hitherto and the challenge is to invent objections in order to develop it in more detail.

In the following different views about how the arrow of time is generated, how self experiences the quantum jumps at lower levels of self hierarchy as a continuous flow of time, and how the contents of sensory experience seem to be localized around a rather narrow interval of geometric time.

The appendix of the book gives a summary about basic concepts of TGD with illustrations. Pdf representation of same files serving as a kind of glossary can be found at <http://tgdtheory.fi/tgdglossary.pdf> [L21].

5.2 The Most Recent Vision About Zero Energy Ontology And P-adicization

The generalization of the number concept obtained by fusing real and p-adics along rationals and common algebraics is the basic philosophy behind p-adicization. One must be able to speak about rational points common to real and various p-adic variants of H . The basic objection is the necessity to fix some special coordinates in turn implying the loss of a manifest general coordinate invariance. The isometries of the embedding space could save the situation provided one can identify some special coordinate system in which isometry group reduces to its discrete subgroup. The loss of the full isometry group could be compensated by assuming that WCW is union over sub- WCW s obtained by applying isometries on basic sub- WCW with discrete subgroup of isometries.

The combination of zero energy ontology realized in terms of a hierarchy of causal diamonds (CDs) and hierarchy of Planck constants providing a description of dark matter and leading to a generalization of the notion of embedding space suggests that it is possible to realize this dream. The article [K138] provides a brief summary about recent state of quantum TGD helping to understand the big picture behind the following considerations.

5.2.1 Zero Energy Ontology Briefly

1. The basic construct in the zero energy ontology is the space $CD \times CP_2$, where the causal diamond CD is defined as an intersection of future and past directed light-cones with time-like separation between their tips regarded as points of the underlying universal Minkowski space M^4 . In zero energy ontology physical states correspond to pairs of positive and negative energy states located at the boundaries of the future and past directed light-cones of a particular CD.
2. CDs form a fractal hierarchy and one can glue smaller CDs within larger CDs. This construction recipe when combined with TGD inspired theory of consciousness allows to understand the asymmetry between positive and negative energies and why the arrow of experienced

time corresponds to the arrow of geometric time and why the contents of sensory experience is located to so narrow interval of geometric time. One can imagine evolution to occur as quantum leaps in which the size of the largest CD in the hierarchy of personal CDs increases in such a manner that it becomes sub-CD of a larger CD. p-Adic length scale hypothesis [K138] follows if the values of temporal distance T between tips of CD come in powers of 2^n : $T = 2^n T_0$. This is probably too strong an assumption: a more realistic hypothesis is that the distances are integer multiples of T_0 .

All conserved quantum numbers for zero energy states have vanishing net values. The interpretation of zero energy states in the framework of positive energy ontology is as physical events, say scattering events with positive and negative energy parts of the state interpreted as initial and final states of the event.

3. In the realization of the hierarchy of Planck constants $CD \times CP_2$ is replaced with a Cartesian product of book like structures formed by almost copies of CDs and CP_2 s defined by singular coverings and factors spaces of CD and CP_2 with singularities corresponding to intersection $M^2 \cap CD$ and homologically trivial geodesic sphere S^2 of CP_2 for which the induced Kähler form vanishes. The coverings and factor spaces of CDs are glued together along common $M^2 \cap CD$. The coverings and factors spaces of CP_2 are glued together along common homologically non-trivial geodesic sphere S^2 . The choice of preferred M^2 as subspace of tangent space of X^4 at all its points and interpreted as space of non-physical polarizations, brings M^2 into the theory also in different manner. S^2 in turn defines a subspace of the much larger space of vacuum extremals as surfaces inside $M^4 \times S^2$.
4. WCW (the world of classical worlds, WCW) decomposes into a union of sub- WCW s corresponding to different choices of M^2 and S^2 and also to different choices of the quantization axes of spin and energy, color isospin and hyper-charge for each choice of this kind. This means breaking down of the isometries to a subgroup. This can be compensated by the fact that the union can be taken over the different choices of this subgroup.
5. p-Adicization requires a further breakdown to discrete subgroups of the resulting sub-groups of the isometry groups but again a union over sub- WCW s corresponding to different choices of the discrete subgroup can be assumed. Discretization relates also naturally to the notion of number theoretic braid.

5.2.2 WCW Spinor Fields

In TGD framework zero energy states correspond to the modes of completely classical WCW spinor fields with fermionic second quantization at space-time level having purely geometric interpretation at the level of WCW. The analysis of the degrees of freedom involved demonstrates that WCW spinor fields are analogous to ordinary quantum fields but have infinite number of components.

1. WCW decomposes to a sub- WCW s association with unions of causal diamonds (CDs). Individual CD is partially characterized by the moduli defined by the positions of its upper and lower tips. The proposal is that the temporal distances between the tips are quantized in octaves of CP_2 time scale and thus coming in good approximation as secondary p-adic time scales for primes very near to power of two. The most general proposal is that also the position of the upper tip at proper time = constant hyperboloid of future light-cone M^4_+ is quantized for positive energy states. For negative energy states this happens to the lower tip. This discrete set would provide a discretized quantum version of Robertson-Walker cosmology with discretized lattice like structure replacing the continuum. The interpretation would be that first tip corresponds to the usual Minkowski space-time of special relativity and the discretized position of second tip - or rather the space M^4_+ representing the relative position of the tips- to the space-time of cosmology. This implies very strong predictions such as the quantization of cosmic redshifts which is indeed observed [K112]. Similar quantization would take place in CP_2 degrees of freedom for either tip. WCW spinor fields for single CD would depend on these moduli and for positive (negative) states one would have wave functions in the space formed by sub- WCW s with wave function basis consisting of products of plane waves in M^4 with a wave function in the discrete subset of M^4_\pm . These degrees of freedom

generalize those of a quantum field in Minkowski space. If the upper tip is assigned with observer, the sub-CDs in the interior of CD correspond to astrophysical objects and M_+^4 as empty Robertson-Walker cosmology predicts automatically cosmic redshift.

2. The notion of generalized imbedding space forces to assign to a given CD a selection of quantization axis of energy and spin which in the case of M^4 boils down to a choice of a preferred plane $M^2 \subset M^4$ plus a choice of time direction (rest system). In the case of CP_2 the choice of quantization axes of color isospin and hypercharge means a choice of a homologically trivial geodesic sphere of CP_2 plus preferred isospin quantization axes. The space for possible choices of quantization axis defines additional moduli. The selection of quantization axes in state function reduction means a localization in these degrees of freedom. The space characterizing the selections of color quantization axis represents an example of so called flag manifold. It has already earlier appeared in TGD inspired biology with a motivation coming from the observation of topologists Barbara Shipman that the mathematical model for honeybee dance leads naturally to the introduction of this space. Shipman speculated that quarks have some role in biology [A6]. Dark matter hierarchy indeed makes indeed possible scaled up copies of QCD type theory in biological length scales.
3. WCW spinor fields restricted to a CD with fixed moduli have infinite number of bosonic and fermionic degrees of freedom. Spin-like degrees of freedom for these fields correspond to WCW spinors, which describe many-fermion states consisting of quarks and leptons and bosons defined as their bound states. This Fock state is assigned to each 3-surface and the dependence on 3-surface defines purely bosonic (“orbital”) degrees of freedom, which can be coded by using a state basis whose elements have well-defined spin and color quantum numbers. The bosonic and fermionic degrees of freedom are super-symmetrically related.

Is it really possible to speak about zero energy states for a given sector defined by generalized embedding space with fixed M^2 and S^2 ? Classically this is possible and conserved quantities are well defined. In quantal situation the presence of the light-cone boundaries breaks full Poincare invariance although the infinitesimal version of this invariance is preserved. Note that the basic dynamical objects are 3-D light-like “legs” of the generalized Feynman diagrams glued together along their ends at generalized vertices.

5.2.3 Definition Of Energy In Zero Energy Ontology

The approach relying on the two super conformal structures of quantum TGD gives hopes of defining the notion of energy for positive and negative energy parts of the state.

1. CD allows translational invariance only in its interior and since partonic two surfaces are located to the boundary of CD, one can argue that translations assigned to them lead out from CD. One can however argue that if it is enough to assign eigenstates of four-momentum to partons and require that only the total four-momentum generators acts on the physical state by shifting CD. Since total four-momentum vanishes for CD this would mean that wave function in cm degrees of CD is just constant plane wave. Super-conformal invariance would indeed allow to assign momentum eigenstates to the super-conformal representations.
2. A more stringent condition would be that four-momentum generators act as translation like operators on partons themselves. Since light-like 3-surfaces assignable to incoming and outgoing legs of the generalized Feynman diagrams are the basic objects, one can hope of having enough translational invariance to define the notion of energy. If translations are restricted to time-like translations acting in the direction of the future (past) then one has local translation invariance of dynamics for classical field equations inside δM_\pm^4 as a kind of semigroup. Also the M^4 translations leading to interior of X^4 from the light-like 2-surfaces surfaces act as translations. Classically these restrictions correspond to non-tachyonic momenta defining the allowed directions of translations realizable as particle motions. These two kinds of translations can be assigned to super-symplectic conformal symmetries at $\delta M_\pm^4 \times CP_2$ and and super Super-Kac-Moody type conformal symmetries acting as super-symplectic isometries. Super-symplectic algebra is realized in terms of second quantized spinor fields and

covariantly constant modes of right-handed neutrino. Symplectic group has as sub-group symplectic isometries and the Super-Kac-Moody algebra associated with this group and represented in terms of spinor modes localized to string world sheets plays also a key role in TGD.

Finite M^4 translations to the interior of CD do not respect the shape of the partonic 2-surface. Local M^4 translations vanishing at the boundary of CD however act as Kac-Moody symmetries of the light-like 3-surfaces and reduce physically to gauge transformations: hence one could allow also the deformations of the partonic 2-surface in the interior of the light-like 3-surface. This corresponds to the effective metric 2-dimensionality stating that all information both about the geometry of WCW and quantum physics is carried by the partonic 2-surfaces X^2 resulting as intersections of the light-like 3-surfaces X_l^3 and space-like 3-D surfaces X^3 at the boundaries of CD and the distribution of 4-D tangent planes of X^2 .

3. The condition selecting preferred extremals of Kähler action is induced by a global selection of $M^2 \subset M^4$ as a plane belonging to the tangent space of X^4 at all its points [K31] and interpreted as a plane of nonphysical polarizations so that direct connection with number theory and gauge symmetries emerges. The M^4 translations of X^4 as a whole in general respect the form of this condition in the interior. Furthermore, if M^4 translations are restricted to M^2 , also the condition itself - rather than only its general form - is respected. This observation, the earlier experience with p-adic mass calculations, and also the treatment of quarks and gluons in QCD encourage to consider the possibility that translational invariance should be restricted to M^2 translations so that mass squared, longitudinal momentum and transversal mass squared would be well defined quantum numbers. This would be enough to realize zero energy ontology. Encouragingly, M^2 appears also in the generalization of the causal diamond to a book-like structure forced by the realization of the hierarchy of Planck constant at the level of the embedding space.
4. That the cm degrees of freedom for CD would be gauge like degrees of freedom sounds strange. The paradoxical feeling disappears as one realizes that this is not the case for sub-CDs, which indeed can have non-trivial correlation functions with either upper or lower tip of the CD playing a role analogous to that of an argument of n-point function in QFT description. One can also say that largest CD in the hierarchy defines infrared cutoff.

5.2.4 P-Adic Variants Of The Embedding Space And Adelic Structure Of Space-Time And Embedding Space

The need to fuse p-adic physics with TGD emerged originally from the discovery that p-adic mass calculations based on p-adic thermodynamics give excellent predictions for elementary particle masses if one assumes p-adic length scale hypothesis stating that primes near integer powers of 2 are physically favored [K138]. Later came the interpretation of p-adic physics as cognition cognition. The following somewhat technical construction of p-adic variants of the embedding space provides new insights concerning the understanding of the arrow of geometric time.

1. Rational values of p-adic coordinates are non-negative so that light-cone proper time $a_{4,+} = \sqrt{t^2 - z^2 - x^2 - y^2}$ is the unique Lorentz invariant choice for the p-adic time coordinate near the lower tip of CD. For the upper tip the identification of a_4 would be $a_{4,-} = \sqrt{(t-T)^2 - z^2 - x^2 - y^2}$. In the p-adic context the simultaneous existence of both square roots poses additional conditions on T . For 2-adic numbers $T = 2^n T_0$, $n \geq 0$ (or more generally $T = \sum_{k \geq n_0} b_k 2^k$), would allow to satisfy these conditions, which would be one additional reason for $T = 2^n T_0$ implying p-adic length scale hypothesis. The remaining coordinates of CD are naturally (hyperbolic) cosines and sines of the spherical coordinates θ and ϕ (hyperbolic angle $\eta_{\pm,4}$).
2. The existence of the preferred plane M^2 of un-physical polarizations would suggest that 2-D light-cone proper times $a_{2,+} = \sqrt{t^2 - z^2}$ $a_{2,-} = \sqrt{(t-T)^2 - z^2}$ can be also considered. The remaining coordinates would be naturally $\eta_{\pm,2}$ and cylindrical coordinates (ρ, ϕ) .

3. The p-adically transcendental values of a_4 and a_2 are literally infinite as real numbers and could be visualized as points in infinitely distant geometric future so that the arrow of time might be said to emerge number theoretically.
4. The selection of the preferred quantization axes of energy and angular momentum unique apart from a Lorentz transformation of M^2 would have purely number theoretic meaning in both cases. One must allow a union over sub- WCW s labeled by points of $SO(1,1)$. This suggests a deep connection between number theory, quantum theory, quantum measurement theory, and even quantum theory of mathematical consciousness.
5. In the case of CP_2 there are three real coordinate patches involved [A15]. The compactness of CP_2 allows to use cosines and sines of the preferred angle variable for a given coordinate patch.

$$\begin{aligned}\xi^1 &= \tan(u) \exp(i \frac{(\Psi + \Phi)}{2}) \cos(\frac{\Theta}{2}) , \\ \xi^2 &= \tan(u) \exp(i \frac{(\Psi - \Phi)}{2}) \sin(\frac{\Theta}{2}) .\end{aligned}\tag{5.2.1}$$

The ranges of the variables u, Θ, Φ, Ψ are $[0, \pi/2], [0, \pi], [0, 4\pi], [0, 2\pi]$ respectively. Note that u has naturally only positive values in the allowed range. S^2 corresponds to the values $\Phi = \Psi = 0$ of the angle coordinates.

6. The rational values of the (hyperbolic) cosine and sine correspond to Pythagorean triangles having sides of integer length and thus satisfying $m^2 = n^2 + r^2$ ($m^2 = n^2 - r^2$). These conditions are equivalent and allow the well-known explicit solution [A3]. One can construct a p-adic completion for the set of Pythagorean triangles by allowing p-adic integers which are infinite as real integers as solutions of the conditions $m^2 = r^2 \pm s^2$. These angles correspond to genuinely p-adic directions having no real counterpart. Hence one obtains p-adic continuum also in the angle degrees of freedom. Algebraic extensions of the p-adic numbers bringing in cosines and sines of the angles π/n lead to a hierarchy increasingly refined algebraic extensions of generalized embedding space. Since the different sectors of WCW directly serve as correlates of selves, this means a direct correlation with the evolution of the mathematical consciousness. Trigonometric identities allow to construct points which in the real context correspond to sums and differences of angles.
7. Negative rational values of the cosines and sines correspond as p-adic integers to infinite real numbers and it seems that one use several coordinate patches obtained as copies of the octant ($x \geq 0, y \geq 0, z \geq 0$). An analogous picture applies in CP_2 degrees of freedom.

How the different variants of p-adic embedding space and real embedding space relate to each other? The original guess was that one can speak about real and p-adic space-time sheets and that in intentional action the p-adic space-time sheet transforms to a real one and in the formation of cognitive representation the opposite transformation occurs. The formulation of quantum transition amplitudes to describe this process might be however impossible. Rather, cognition and sensory aspects of the geometric existence are simultaneously present: space-time and embedding space are adelic. This indeed conforms with the success of p-adic mass calculations.

1. What seems clear that there must exist kind of chart mappings between them. The notion of p-adic space-time surface is formulated in [K143]. The idea is that p-adic space-time surfaces are cognitive charts of real space-time surface. Both real and p-adic space-time surfaces satisfy the field equations and are thus preferred extremals of Kähler action. There is discretization due to both number theoretic reasons and the points in discretization correspond to points which are common to reals and p-adic number fields. This includes rationals and algebraic numbers in the extension of p-adic number field.

2. At the level of world of classical worlds (WCW) the discretization would be more abstract since the naïve discretization of higher-dimensional objects can be argued to be zero-dimensional as a point set. The parameters defining the geometric object are rational or in the algebraic extensions of rationals.
3. It is now clear the discretization introduced in [K143] might be too naïve. The above described abstraction applies also to the discretization various objects such as partonic 2-surfaces and their 3-D light-like orbits, string world sheets, space-like 3-surfaces, and space-time surfaces. Co-dimension two rule would apply. Partonic 2-surfaces are replaced with discrete point sets at which the fermion lines identified as boundaries of string world sheets meet. The orbits of partonic 2-surface correspond to fermion lines. Space-time surfaces is discretized to a collection of string world sheets which are in the intersection of reality and p-adicities in the sense that the defining parameters belong are in the algebraic extensions associated with p-adic numbers.

Concerning the construction of preferred extremals this means strong form of holography. One starts from string world sheets (carrying vanishing induced W boson fields so that em charge for the spinor modes is well-defined) and partonic 2-surfaces and continues them to space-time surfaces satisfying field equations for preferred extremals. These include infinite number of conditions stating that the Noether charges of super-symplectic algebra vanish and that the classical conserved charges correspond to the eigenvalues of quantal charges associated with string world sheets. This guarantees the generalization of AdS/CFT correspondence. The preferred extremal is defined only modulo conformal gauge transformations defining $n = h_{eff}/h$ conformal equivalence classes.

4. All p-adic variants of the space-time surface are present and meet each other along string world sheets, which is like a back of a book. Fermions representing Boolean cognition reside in this intersection and are thus number theoretically universal, which conforms with the fact that the anti-commutation relations for the oscillator operators can be written in a form which does not involve any numbers except unity. One can say that string world sheets and fermions define the fundamental cognitive representations in the intersection of realities and p-adicities. In this intersection also the notion of negentropic entanglement makes sense.
5. One can assign to elementary particles definite value of p-adic prime. For this p-adic prime the p-adic preferred extremal should provide a better representation of real space-time surface than others. The reason could be that the classical nondeterminism of Kähler action for them is very similar to the p-adic non-determinism for the p-adic prime involved. 4-D spin glass character of the landscape of maxima of Kähler function together with the fact that ordinary spin glass landscape consisting of minima of free energy allows ultra-metric topology about which p-adic topologies are examples. This suggests that real preferred extremal obeys some p-adic topology in discretization in some length scale range.

5.3 Zero Energy Ontology, Self Hierarchy, And The Notion Of Time

Consider now the formulation of TGD inspired quantum theory of consciousness [L10] and quantum biology [L8] in terms of zero energy ontology.

One should understand the asymmetry between positive and negative energies and between two directions of geometric time at the level of conscious experience, the correspondence between experienced and geometric time, and the emergence of the arrow of time. One should explain why human sensory experience is about a rather narrow time interval of about 1 seconds and why memories are about the interior of much larger CD with time scale of order life time. One should have a vision about the evolution of consciousness: how quantum leaps leading to an expansion of consciousness occur.

Negative energy signals to geometric past - about which phase conjugate laser light represents an example - provide an attractive tool to realize volitional action as a signal inducing neural activities in the geometric past (this would explain Libet's classical findings), a mechanism of

remote metabolism, and the mechanism of declarative memory as communications with geometric past. One should understand how these signals are realized in zero energy ontology and why their occurrence is so rare.

In the following I try to demonstrate that TGD inspired theory of consciousness and quantum TGD proper indeed are in tune.

5.3.1 Space-Time And Embedding Space Correlates For Selves

Quantum jump as a moment of consciousness, self as a sequence of quantum jumps integrating to self, and self hierarchy with sub-selves experienced as mental images, are the basic notions of TGD inspired theory of consciousness. In the most ambitious vision self hierarchy reduces to a fractal hierarchy of quantum jumps within quantum jumps. Quantum classical correspondence demands selves to have space-time correlates both at the level of space-time and embedding space.

At the level of space-time the first guess for the correlates is as light-like or space-like 3-surfaces. If one believes on effective 2-dimensionality and quantum holography, partonic 2-surfaces plus their 4-D tangent space distribution would code the information about the space-time correlates. By quantum classical correspondence one can also identify space-time sheets as the correlates modulo the gauge degeneracy implied by super-conformal symmetries.

It is natural to interpret CDs as correlates of selves at the level of the embedding space. CDs can be interpreted either as subsets of the generalized embedding space or as sectors of WCW. Accordingly, selves correspond to CDs of the generalized embedding space or sectors of WCW, literally separate interacting quantum Universes. The spiritually oriented reader might speak of Gods. Sub-selves correspond to sub-CDs geometrically. The contents of consciousness of self is about the interior of the corresponding CD at the level of embedding space. For sub-selves the wave function for the position of tip of CD brings in the de-localization of sub- WCW.

The fractal hierarchy of CDs within CDs is the geometric counterpart for the hierarchy of selves: the quantization of the time scale of planned action and memory as $T(k) = 2^k T_0$ suggest an interpretation for the fact that we experience octaves as equivalent in music experience. This assumption is however un-necessarily restrictive. In order to understand interactions between selves one must also allow intersections of CDs. The interactions would correspond to the formation of magnetic flux tubes contacts between the 3-surfaces involving also strings connecting the partonic 2-surfaces and defining string world sheets.

It seems that string world sheets can be identified as the intersection of space-time surfaces in various number fields identified as preferred extremals of Kähler action. They would define the fundamental cognitive representations. Therefore partonic 2-surfaces and string world sheets would serve also as cognitive representation of selves and the negentropic entanglement would be associated the fermions at them serving as correlates of Boolean cognition. To be in the intersection of various number fields would mean in the case of string world sheets and partonic two-surfaces that the parameters characterizing them are algebraic numbers in the extension of p-adic numbers. This suggests that the algebraic continuation to all possible p-adic number fields is not possible. Maybe those p-adic primes for which this is possible characterize the particle. By generalized conformal invariance the algebraic values of conformal moduli of partonic 2-surfaces and string world sheets could define the parameters in question so that the situation would reduce to finite-dimensional one.

5.3.2 Weak Form Of NMP

The notion of number theoretic entropy obtained by can be defined by replacing in Shannon entropy the logarithms of probabilities p_n by the logarithms of their p-adic norms $|p_n|_p$. This replacement makes sense for algebraic entanglement probabilities if appropriate algebraic extension of p-adic numbers is used. What is new that entanglement entropy can be negative, so that algebraic entanglement can carry information and NMP can force the generation of bound state entanglement so that evolution could lead to the generation of larger coherent bound states rather than only reducing entanglement. A possible interpretation for algebraic entanglement is in terms of experience of understanding or some positive emotion like love.

Standard formalism of physics lacks a genuine notion of information and one can speak only about increase of information as a local reduction entropy. It seems strange that a system gaining

wisdom should increase the entropy of the environment. Hence number theoretic information measures could have highly non-trivial applications also outside the theory consciousness.

NMP combined with number theoretic entropies leads to an important exception to the rule that the generation of bound state entanglement between system and its environment during U process leads to a loss of consciousness. When entanglement probabilities are rational (or even algebraic) numbers, the entanglement entropy defined as a number theoretic variant of Shannon entropy can be non-positive (actually is) so that entanglement carries information. NMP favors the generation of algebraic entanglement. The attractive interpretation is that the generation of algebraic entanglement leads to an expansion of consciousness (“fusion into the ocean of consciousness”) instead of its loss.

State function reduction period of the quantum jumps involves much more than in wave mechanics. For instance, the choice of quantization axes realized at the level of geometric delicacies related to CDs is involved. U -process generates a superposition of states in which any sub-system can have both real and algebraic entanglement with the external world. If state function reduction involves also a choice between generic and negentropic entanglement (between real world, a particular p -adic world, or their intersection) it might be possible to identify a candidate for the physical correlate for the choice between good and evil. The hedonistic complete freedom resulting as the entanglement entropy is reduced to zero on one hand, and the algebraic bound state entanglement implying correlations with the external world and meaning giving up the maximal freedom on the other hand. The hedonistic option is risky since it can lead to non-algebraic bound state entanglement implying a loss of consciousness. The second option means expansion of consciousness - a fusion to the ocean of consciousness as described by spiritual practices. Note that if the total entanglement negentropy defined as sum of contributions from various levels of CD hierarchy up to the highest matters in NMP then also sub-selves should develop negentropic entanglement. For instance, the generation of entropic entanglement at cell level can lead to a loss of consciousness also at higher levels. Life would evolve from short to long scales.

The consistency with quantum measurement theory leads to an important constraint on the density matrix giving rise to negentropic entanglement. The density matrix of the final state must be a projector as in the ordinary quantum measurement theory. Its dimension can be however higher than one now. Therefore negentropic entanglement cannot be confused with real entanglement and there is no problem due to the fact that for real number based entanglement it is impossible to know in practice whether the entanglement coefficients are rational numbers. The entanglement giving rise to a density matrix, which is projector corresponds in the 2-particle case entanglement matrix proportional to unitary matrix typical for quantum computer type systems.

TGD inspired theory of consciousness forces to challenge the hypothesis that NMP always forces the state function reduction to the sub-space defined by the projector with maximal dimension appearing in the decomposition of the density matrix. NMP would not allow the self to make choices, which are bad deeds in the sense that they do not increase maximally the negentropic resources of the Universe. We would live in the best possible Universe becoming better all the time. This is obviously too good to be true.

A weaker form of NMP allows the choice leading to maximal negentropy gain but allows also those choices for which the reduction occurs to a sub-space of the space defined by projector. When this sub-space is 1-dimensional standard quantum measurement results and the self is isolated from the target of observations. Negentropic entanglement has interpretation as attention with positively colored contents of consciousness. Experience of love would be one attribute of this kind of state. Weak form of NMP would be like God allowing the sinner to chose between Good and Evil.

5.3.3 Conscious Entities And Arrow Of Time In TGD Universe

“Fractality from your blog” posed an interesting question about possible asymmetry between boundaries of causal diamond CD. The answer to the question led to recall once again the incomplete understanding of details about how the arrow of time emerges in zero energy ontology (ZEO).

The basic vision is following.

1. CDs form a fractal scale hierarchy. Zero energy states possess a wave function in moduli degrees of freedom characterizing sizes of CDs as well telling what Lorentz boost leaving

boundary invariant are allowed for them. Boosts form by number theoretic constraints a discrete subgroup of Lorentz group defining analogs of lattices generated by boosts instead of translations.

2. The arrow of subjective time maps to that of geometric time somehow. The origin of arrow comes from the fact that state function reductions can occur to either boundary of given CD and reduction creates time-asymmetric state since second boundary of CD is in a quantum superposition of different sizes and there is a superposition of many-particle states with different particles numbers and quantum number distributions. It is possible that each state function reduction leaving the passive boundary intact, involves localization in the moduli space of CDs with second boundary fixed.
3. Subjective existence corresponds to a sequence *of moments of consciousness*: state function reductions at opposite boundaries of CDs. State function reduction localizes either boundary but the second boundary is in a quantum superposition of several locations and size scales for CD. This predicts that the arrow of time is not constant. In fact, there is considerable evidence for the variation of the arrow of time in living systems and Fantappie [J92] introduced long time ago the notion of syntropy to describe his view about the situation.
4. The first very naïve proposal was that state function reductions occur *alternately* to the two boundaries of CD. This assumption would be indeed natural if one considered single fixed CD rather than superposition CDs with different size and state function reduction localizing their either boundary: restriction to single CD was what I indeed did first.
5. This assumption leads to the question about why do we do not observe this alternation of the arrow of time all the time in our personal experience. Some people actually claim to have actually experienced a temporary change of the arrow of time: I belong to them and I can tell that the experience is frightening. But why do we experience the arrow of time as stable in the standard state of consciousness?

One possible way to solve the problem - perhaps the simplest one - is that state function reduction to the same boundary of CD can occur many times repeatedly. This solution is so absolutely trivial that I could perhaps use this triviality to defend myself for not realizing it immediately!

I made this totally trivial observation only after I had realized that also in this process the wave function in the moduli space of CDs change in these reductions. Zeno effect in ordinary measurement theory relies on the possibility of repeated state function reductions. In the ordinary quantum measurement theory repeated state function reductions do not affect the state in this kind of sequence but in ZEO the wave function in the moduli space labelling different CDs with the same boundary could change in each quantum jump. It would be natural that this sequence of quantum jumps give rise to the experience about flow of time? This option would allow the size scale of CD associated with human consciousness be rather short, say, 1 seconds. It would allow to understand why we do not observe continual change of arrow of time.

Maybe living systems are working hardly to keep the personal arrow of time un-changed - living creatures try to prevent kettle from boiling by staring at it intensely. Maybe it would be extremely difficult to live against the collective arrow of time.

An objection against this picture as compared to the original one assuming alternate reductions to the opposite boundaries of CD is that is that one can understand state preparation as state function reduction to the opposite boundary. This interpretation makes sense almost as such also in the new picture if the average time period for which the reductions occur to a given boundary is shorter in elementary particles scales than in macroscopic scales characteristic for human consciousness. The approximate reversibility in elementary particle scales can be understood as summing up of the two arrows of time to no arrow at all.

This picture allows also to identify self as a continuous entity as the sequence of state function reductions occurring at the same boundary of CD. The average increase of the temporal distance between the tips of cD defines the life-time of self. The number of reductions would give a measure for the subjectively experienced of life-time of self.

In elementary particle time scales reversibility is a good approximation and this suggests that in elementary particle scales the number of state function reductions at the same boundary of CD is small so that the effects due to the change of the arrow of time cancel on the average.

NMP would eventually force "death" of self since the state function reduction at opposite boundary would generate more negentropy. "Death" of self would mean birth of self associated with the opposite boundary of CD. The age of self identified as the proper time distance between the tips would increase in statistical sense even when its arrow can change. The act of volition would have a natural identification as the first state function reduction at the opposite boundary of CD.

This picture raises a series of questions. Do our wake-up periods correspond to sequences of state function reductions for self and are sleeping periods wake-up periods of the self at the opposite boundary of CD? The arrow of geometric time should change at some space-time sheet associated with the self hierarchy. How could one demonstrate this? Are the memories of the "other" self predictions of future from our point of view? Do we sleep in order to get information from future, to remember what the future will be?

How the hierarchy of Planck constants defining a hierarchy of quantum criticalities does relate to this picture? The ageing of self having has as a correlate the increase of the size scale of CD. Could this increase be due to the increase of h_{eff} expected to occur spontaneously since it corresponds to a reduction of criticality and therefore to the appearance of new physical degrees of freedom as symplectic gauge degrees of freedom transform to physical ones in gauge symmetry breaking. This is not the case. The time evolution must be analogous to shift in time rather than scaling. This of course corresponds to the QFT view about time evolution.

In the first state function reduction to the opposite boundary of CD however scaling of CD is possible and would correspond to the scaling of CD represented by exponent of infinitesimal scaling operator as in conformal field theories. The emergence of new physical degrees of freedom suggest increasing perceptive and cognitive capabilities. The increase of h_{eff} could be seen as evolution as also the associated increase of resources of negentropic entanglement suggests. The total increase of h_{eff} measured by the ratio $h_{eff}(final)/h_{eff}(initial)$ could be seen as a measure for the progress per single life period of self.

5.3.4 Why Sensory Experience Is About So Short Time Interval?

CD picture implies automatically the 4-D character of conscious experience and memories form part of conscious experience even at elementary particle level. Amazingly, the secondary p-adic time scale of electron is $T = 0.1$ seconds defining a fundamental time scale in living matter. The problem is to understand why the sensory experience is about a short time interval of geometric time rather than about the entire personal CD with temporal size of order life-time. The explanation would be that sensory input corresponds to sub-selves (mental images) with $T \simeq .1$ s at the upper light-like boundary of CD in question. This requires a strong asymmetry between upper and lower light-like boundaries of CDs. Certainly this time scale is only minimal CD time scale assignable to electron and the time evolution of electron self should increase this time scale, which would however increase also in the first state function reduction to the opposite boundary of electronic CD.

The localization of the contents of the sensory experience to the upper light-cone boundary and local arrow of time could emerge as a consequence of self-organization process involving conscious intentional action. Sub-CDs would be in the interior of CD and self-organization process would lead to a distribution of CDs concentrated near the upper or lower boundary of CD. The local arrow of geometric time would depend on CD and even differ for CD and sub-CDs.

1. The localization of contents of sensory experience to a narrow time interval would be due to the concentration of sub-CDs representing mental images near the either boundary of CD representing self.
2. Phase conjugate signals identifiable as negative energy signals to geometric past are important when the arrow of time differs from the standard one in some time scale. If the arrow of time establishes itself as a phase transition, this kind of situations are rare. Negative energy signals as a basic mechanism of volitional action and transfer of metabolic energy would explain why living matter is so special.

3. Geometric memories would correspond to sub-selves in the interior of CD, the oldest of them to the regions near “lower” boundaries of CD. Since the density of sub-CDs is small there geometric memories would be rare and not sharp. A temporal sequence of mental images, say the sequence of digits of a phone number, would correspond to a temporal sequence of sub-CDs.
4. Sharing of mental images corresponds to a fusion of sub-selves/mental images to single sub-self by quantum entanglement: the space-time correlate could be flux tubes connecting space-time sheets associated with sub-selves represented also by space-time sheets inside their CDs.

5.3.5 The Mechanism Of Self Reference

Self reference is perhaps the most mysterious aspect of conscious experience. When formulated in somewhat loose manner self reference states that self can be conscious about being conscious of something. When trying to model this ability in say computer paradigm one is easily led to infinite regress. In TGD framework a weaker form of self referentiality holds true: self can become conscious that it *was* conscious of something in previous quantum jump(s). Self reference therefore reduces to memory. Infinite regress is replaced with evolution recreating Universe again and again and adding new reflective levels of consciousness. It is however essential to have also the experience that memory is in question in order to have self reference. This knowledge implies that a reflective level is in question.

The mechanism of self reference would reduce to the ability to code information about quantum jump into the geometry and topology of the space-time surface and to the quantum entanglement assignable the fermions. This representation defines an analog of written text which can be read if needed: memory recall is this reading process. The existence of this kind of representations means quantum classical correspondence in a generalized sense: not only quantum states but also quantum jump sequences responsible for conscious experience can be coded to the space-time geometry. The reading of this text induces self-organization process re-generating the original conscious experience or at least some aspects of it (say verbal representation of it). The failure of strict classical determinism for Kähler action is absolutely essential for the possibility to realize quantum classical correspondence in this sense.

Consider now the problem of coding conscious experience to space-time geometry and topology so that it can be read again in memory recall. Let us first list what I believe to know about memories.

1. In TGD framework memories corresponds to sub-CDs inside CDs and are located in geometric past. This means fundamental difference from neuroscience view according to which memories are in the geometric now. Note that standard physicist would argue that this does not make sense: by the determinism of field equations one cannot think 4-dimensionally. In TGD however field equations fail to be deterministic in the standard sense: this actually led to the introduction of zero energy ontology.
2. The reading wakes up mental images which are essentially 4-D self-organization patterns inside sub-CDs in the geometric past. Metabolic energy is needed to achieve this wake up. What is needed is generation of space-time sheets representing the potential images making possible memories.

This picture combined with the mechanism for generating the arrow of psychological time and explaining why sensory experience is located to so short time interval as it is (.1 second, the time scale of CD associated with electron by p-adic length scale hypothesis) allows to understand the mechanism of self reference. It deserves to be mentioned that the discussion with Stephen Paul King in Time discussion group served as the midwife for this step of progress.

1. When the film makes a shift to the direction of geometric past in quantum jump sub-selves representing mental images representing the reaction to the “news” are generated. These correspond to sub-CDs contains space-time surfaces as correlates of sub-selves created and the information contents of immediate conscious experiences is about this region of space-time and embedding space. They are like additional comment marks on the film giving information about what feelings the news from the geometric future stimulated.

2. In subsequent quantum jumps film moves downwards towards geometric past and markings defined in terms of space-time correlates for mental images are shifted backwards with the film and define the coding of information about previous conscious experience. In memory recall metabolic energy is fed to these subsystems and they wake up and regenerate the mental images about the remembered aspect of the previous conscious experience. This would not be possible in positive energy ontology and if determinism in strict sense of the world would hold true.
3. Something must bring in the essential information that these experiences are memories rather than genuine sensory experiences (say). Something must distinguish between genuine experiences and memories about them. The space-time sheets representing self reference define cognitive representations. If the space-time sheets representing the correlates for self-referential mental images are p-adic, this distinction emerges naturally. That these space-time sheets are in the intersection of real and p-adic worlds is actually enough and also makes possible negentropic entanglement (see **Fig.** <http://tgdtheory.fi/appfigures/cat.jpg> or **Fig. ??** in the appendix of this book) carrying the conscious information. In TGD inspired quantum biology this property is indeed the defining characteristic of life.
4. There is quite concrete mechanism for the realization of memories in terms of braidings of magnetic flux tubes discussed in [K3].

Interesting questions relate to the role of p-adicity and the realization of the active aspects of consciousness. One can consider also quantum jumps in which the space-time surface inside CD does not suffer mere passive shift downwards but is affected also in the geometric past. The mechanism of intentional action, which could have been inspired by Libet's finding that neuronal activity seems to precede conscious decision, can be understood in terms of negative energy signals sent to the geometric past, where they generate neuronal activity replacing the space-time surface with a new one.

If p-adicity is involved, the possibility seems that comes to mind is that the space-time sheets representing the signal to the geometric past are first generated as p-adic space-time sheets representing intention and transformed in quantum jump to their real counterparts representing the "desire" for action in turn generating the action.

5.3.6 Can Selves Interact And Evolve?

Interesting questions relate to how dynamical selves are.

1. Is self doomed to live inside the same sub- WCW eternally as a lonely god? This question has been already answered: there are interactions between sub-CDs of given CD, and one can think of selves as quantum superposition of states in CDs with wave function having as its argument the tips of CD, or rather only the second one since T is assumed to be quantized.
2. Is there largest CD in the personal CD hierarchy of self in an absolute sense? Or is the largest CD present only in the sense that the contribution to the contents of consciousness coming from very large CDs is negligible? Long time scales T correspond to low frequencies and thermal noise might mask these contributions. Here however the hierarchy of Planck constants and generalization of the embedding space could come in rescue by allowing dark EEG photons to have energies above thermal energy.
3. Can selves evolve in the sense that the size of CD increases in quantum leaps so that the corresponding time scale $T = 2^k T_0$ of memory and planned action increases? Geometrically this kind of leap would mean that CD becomes a sub-CD of a larger CD - either at the level of conscious experience or in absolute sense. The leap can occur in two senses: as an increase of the largest p-adic time scale in the personal hierarchy of space-time sheets or as increase of the largest value of Planck constants in the personal dark matter hierarchy. At the level of individual organism this would mean emergence of new lower frequencies of generalized EEG and levels of personal dark matter hierarchy with larger value of Planck constant.

5.3.7 Questions And Answers

Answering to question is the best possible manner to develop ideas in more comprehensible form. In this respect the questions of Hamed at my blog have been especially useful. Many questions below are originally made by him and inspired the objections, many of them discussed also in previous discussions. The answers to these questions have changed during latest years as the views about self and the relation between experienced time and geometric time have developed. The following answers are the most recent ones.

Question: The minimalistic option suggests very strongly that our sensory perception can be identified as quantum measurement assignable to state function reductions for upper or lower boundaries of our personal CD. Our sensory perception does not however jump between future and past boundaries of our personal CD (containing sub-CDS in turn containing...)! Why?

Possible answer: The answer to this question comes from the realization that in ordinary quantum theory state function reductions leaving the reduced state invariant are possible. This must have counterpart in ZEO. In ZEO reduces zero energy states are superpositions of zero energy states associated with CDs with second boundary fixed inside light-cone boundary and the position of the second boundary of CD varying: one can speak about wave function in the moduli space of CDs. The temporal distance between the tips of CD and discrete lattice of the 3-D hyperbolic space defined by the Lorentz boosts leaving second tip invariant corresponds to the basic moduli.

The repeated state function reductions leave both the fixed boundary and parts of zero energy states associated with this boundary invariant. They however induce dispersion in the moduli space and the average temporal distance between the tips of CDs increases. This gives rise to the flow of psychological time and to the arrow of time. Self as counterpart of observer can be identified as a sequence of quantum jumps leaving the fixed boundary of CD invariant. Sensory perception gives information about varying boundary and the fixed boundary creates the experience about self as invariant not changed during quantum jumps.

The repeated reductions must do something for the state and the simplest assumption is that they induce localization in the moduli space of CDs. The time evolution operator inducing the superposition could be analogous to exponent of translation generator appearing in quantum field theories.

Self hierarchy corresponds to the hierarchy of CDs. For instance, we perceive from day to day the - say- positive energy part of a state assignable to this very big CD. Hence the world looks rather stable.

Question: This suggests that our sensory perception actually corresponds to sequences of state function reductions to the two fixed boundaries of CDs of superposition of CDs so that our sensory inputs would alternately be about upper and lower boundaries of personal CDs. Sleep-awake cycle could correspond to a flip flop in which self falls asleep at boundary and wakes up at opposite boundary. Doesn't this lead to problems with the arrow of time?

Possible answer: If we measure time relative to the fixed boundary then the geometric time defined as the average distance between tips in superposition of CDs would increase steadily and we get older also during sleep. Hence we would experience subjective time to increase. Larger CDs than our personal CD for which the arrow of time remains fixed in the time scale of life cycle would provide the objective measure of geometric time.

Question: What is the time scale assignable to my personal CD: the typical wake-up cycle: 24 hours? Or of the order of life span. Or perhaps shorter?

Possible answer: The durations of wake-up periods for self is determined by NMP: death means that NMP favors the next state function to take place at the opposite boundary. The first naïve guess is that the duration of the wake up period is of the same order of magnitude as the geometric time scale of our personal CD. In wake-up state we would be performing state function reduction repeatedly to say "lower" boundary of our personal CD and sensory mental images as sub-CDs would be concentrated near opposite boundary. During sleep same would happen at lower boundary of CD and sensory mental images would be at opposite boundary (dreams, ...).

Question: Are dreams sensory perceptions with opposite arrow of time or is some sub-self in wake-up state and experiences same arrow of time as we during wake-up state? If the arrow is

different in dreams, is the “now” of dreams in past and “past” in the recent of wake-up state

Possible answer: Here I can suggest an answer based on my own subjective experiences and it would be cautious “yes”.

Question: Why we do remember practically nothing about sensory perceptions during sleep period? (Note that we forget actively dream experiences).

Possible answer: That we do not have many memories about sleep and dream time existence and that these memories are unstable should relate to the change of the arrow of personal time as we wake up. Wake-up state should somehow rapidly destroy the ability to recall memories about dreams and sleep state. Wake-up memory recall means communications to geometric past, that is to the boundary of CD which remains fixed during wake-up state. In memory recall for dreams in wake-up state these communications should take place to geometric future. Memory recall of dreams would be seeing to future and much more difficult since the future is changing in each state function reduction so that dream memories are erased automatically during wake-up.

Question: Does the return to childhood at old age relate with this time flip-flop of arrow of time in the scale of life span: do we re-incarnate in biologically death at opposite end of CD with scale of life span?

Possible answer: Maybe this is the case. If this boundary corresponds to time scale of life cycle, the memories would be about childhood. Dreams are often located to the past and childhood.

5.4 What Does Arrow Of Time Mean At The Level Of Quantum States?

The previous discussion does not touch the question what arrow of time means at the level of quantum states. Therefore the notion of negative energy signal propagating backwards in geometric time crucial for TGD inspired quantum biology remains somewhat fuzzy. The recent progress in the understanding of the basic properties of zero energy states makes it possible to understand what arrow of geometric time and the notion of negative energy state and signals propagating to the direction of geometric past mean at the level of zero energy states. This understanding has surprisingly non-trivial philosophical implications.

5.4.1 Arrow Of Time As An Inherent Property Of Zero Energy States

The basic idea can be expressed in very concise form. In positive energy ontology arrow of time characterizes dynamics. In zero energy ontology arrow of time characterizes quantum states.

1. The breaking of time reversal invariance means that zero energy states can be localized with respect to particle number and other quantum numbers only for future or past light-like boundary of CD but not both. M -matrix generalizing S -matrix provides the time-like entanglement coefficients expressing the state at the second boundary as quantum superposition of states with well-defined particle numbers and other quantum numbers. But only at the second end of CD since one cannot choose freely the states at both boundaries: if this were the case the counterpart of Schrödinger equation would be completely non-deterministic. This is what the breaking of time reversal symmetry means. It occurs spontaneously and assigns to the arrow of subjective time geometric arrow of time.

This picture gives a precise meaning to the arrow of geometric time and therefore also for the otherwise fuzzy notion of negative energy signals propagating backwards in space-time playing key role in TGD based models of memory, metabolism, and intentional action [?]

2. Quantum jump begins with the unitary U-process between zero energy states generating a superposition of zero energy states. After that follows state function reduction cascade proceeding from the level of CD to the level of sub-CDs forming a fractal hierarchy. The reductions cannot take independently at both light-like boundaries of CD as is also clear from the fact that scattering state leads from a prepared state to a quantum superposition of prepared states.

The first guess is that the cascade takes place for the second boundary of CD only so that the arrow of geometric time would be same in all scales. This need not be the case always: the geometric arrow of time seems to change in some situations: phase conjugate laser light and spontaneous self-assembly of bio-molecules are good examples about this [K136, ?]. In fact, one of the defining properties of living matter could be just the possibility that the arrow of geometric time is not same in all scales (size scales of CDs) so that memory, metabolism, and intentional action become possible. In any case, the second end remains a superposition of quantum states.

The lack of quantum measurements at the second end of space-times could explain why the conscious percepts are sharply localized in time at the second end of CD. This could also allow to understand memories as reductions occurring at the second, non-standard, end of sub-CDs in the geometric past.

3. The correspondence between the reduced state and the quantum superposition of states at the opposite boundary of CD allows an interpretation in terms of logical implication arrow with all statements present in the superposition implying the statement represented by the reduced state. Only implication arrow rather than equivalence is possible unless the M -matrix is diagonal meaning that there are no interactions. If it is possible to diagonalize M -matrix then in diagonal basis one has equivalences. It must be however emphasized that the physically preferred state basis fixed as in terms of eigenstates of density matrix does not allow diagonal M -matrix. Number theoretic conditions required that the density matrix corresponds to fixed algebraic extension of rationals can also make possible the diagonalization without leaving the extension and this condition might be highly relevant in the TGD inspired view about cognition relying on p -adic number fields and their algebraic extensions [K120].
4. In classical logic implication corresponds to the inclusion of subset by subset. In quantum case it corresponds to the inclusion for sub-space of state space. The inclusions of hyper-finite factors (WCW spinors define HFF of type II_1) realize the notion of finite measurement resolution, which would suggest that inclusion arrow has also interpretation in terms of finite measurement resolution.

All quantum states equivalent with a given state in the resolution used imply it. Finite measurement resolution would mean that there would infinite number of instances always in the quantum superposition representing the rule $A \rightarrow B$. Ironically, both finite measurement resolution and dissipation implying the arrow of geometric time and usually regarded as something negative from the point of view of information processing would be absolutely essential element of logical thinking in this framework.

5. Conscious theorem proving would have as correlate to building of sequences zero energy states representing $A \rightarrow B$, $B \rightarrow C$, $C \rightarrow D$ with basic building bricks representing simple basic rules. These sequences would represent more complex truths.

5.4.2 Does State Function-State Preparation Sequence Correspond To Alternating Arrow Of Geometric Time?

The state function reduction at light-like boundary of CD implies de-localization at the opposite boundary. This inspires so fascinating questions.

1. Could the state function reduction process take place alternately at the two boundaries of CD so that a kind of flip-flop in which the arrow of geometric time changes back and forth would result, and have interpretation as an alternating sequence of state function reductions and state preparations in the framework of positive energy ontology?
2. State function reductions are needed for sensory percepts. Could the sleep-wake-up period correspond to this kind of process so that during what we call sleep the past boundary of our personal CD would be in wake-up state? Could dreams and memories represent sharing of mental images of this kind of consciousness? Could it be that in the time scale of entire life cycle death is accompanied by birth at the second boundary of personal CD? Could this quantum physics representation for endless sequence of deaths and rebirths? Could

the fact that old people often spend they last years in childhood have interpretation in this framework?

3. State preparation-reduction cycle might characterize only living matter whereas for inanimate matter second choice for the arrow of time would be dominant between two U-processes. TGD based reformulation [K134] of entropic gravity idea of Verlinde [B5] in terms of ZEO does not assume the absence of gravitons and the emergence of space-time. The formulation leads to the proposal that thermodynamical stability selects the arrow of the geometric time and that it could be different for matter and antimatter implying that matter and antimatter reside at different space-time sheets. This would explain the apparent absence of antimatter and also support the view that the arrow alternates only in living matter. Note that state preparation also corresponds to intentional action not possible in the world of standard thermodynamics with fixed arrow of thermodynamical time.

5.4.3 Or Does “Dispersion” At Second Boundary Of CD Cause Generate The Arrow Of Time?

“Fractality from your blog” posed an interesting question about possible asymmetry between boundaries of causal diamond CD. The answer to the question led to recall once again the incomplete understanding of details about how the arrow of time emerges in zero energy ontology (ZEO).

The basic vision is following.

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2. The arrow of subjective time maps to that of geometric time somehow. The origin of arrow comes from the fact that state function reductions can occur to either boundary of given CD and reduction creates time-asymmetric state since second boundary of CD is in a quantum superposition of different sizes and there is a superposition of many-particle states with different particles numbers and quantum number distributions.
3. Subjective existence corresponds to a sequence of *moments of consciousness*: state function reductions at opposite boundaries of CDs. State function reduction reduction localizes either boundary but the second boundary is in a quantum superposition of several locations and size scales for CD. This predicts that the arrow of time is not constant. In fact, there is considerable evidence for the variation of the arrow of time in living systems and Fantappie introduced long time ago the notion of syntropy to describe his view about the situation.
4. The first very naïve proposal was that state function reductions occur *alternately* to the two boundaries of CD. This assumption would be indeed natural if one considered single fixed CD rather than superposition CDs with different size and state function reduction localizing their either boundary: restriction to single CD was what I indeed did first.
5. This assumption leads to the question about why do we do not observe this alternation of the arrow of time all the time in our personal experience. Some people actually claim to have actually experienced a temporary change of the arrow of time: I belong to them and I can tell that the experience is frightening. But why do we experience the arrow of time as stable in the standard state of consciousness?

One possible way to solve the problem - perhaps the simplest one - is that state function reduction to the same boundary of CD can occur many times repeatedly. This solution is so absolutely trivial that I could perhaps use this triviality to defend myself for not realizing it immediately!

I made this totally trivial observation only after I had realized that also in this process the wave function in the moduli space of CDs change in these reductions. Zeno effect in ordinary

measurement theory relies on the possibility of repeated state function reductions. In the ordinary quantum measurement theory repeated state function reductions do not affect the state in this kind of sequence but in ZEO the wave function in the moduli space labelling different CDs with the same boundary could change in each quantum jump. It would be natural that this sequence of quantum jumps give rise to the experience about flow of time? This option would allow the size scale of CD associated with human consciousness be rather short, say, 1 seconds. It would allow to understand why we do not observe continual change of arrow of time.

Maybe living systems are working hardly to keep the personal arrow of time changed - living creatures try to prevent kettle from boiling by staring at it intensely. Maybe it would be extremely difficult to live against the collective arrow of time.

An objection against this picture as compared to the original one assuming alternate reductions to the opposite boundaries of CD is that is that one can understand state preparation as state function reduction to the opposite boundary. This interpretation makes sense almost as such also in the new picture if the average time period for which the reductions occur to a given boundary is shorter in elementary particles scales than in macroscopic scales characteristic for human consciousness. The approximate reversibility in elementary particle scales can be understood as summing up of the two arrows of time to no arrow at all.

5.4.4 Quantum Dynamics For The Moduli Of CDs And The Arrow Of Geometric Time

How the arrow of geometric time at the level of space-time and embedding space is induced from the arrow of subjective time identified in terms of sequence of quantum jumps forming a fractal hierarchy of quantum jumps within quantum jumps? This is one of the long lasting puzzles of TGD and TGD inspired theory of consciousness.

In zero energy ontology (ZEO) the geometry of CD (I often use the sloppy notation $CD \equiv CD \times CP_2$, where the latter CD is defined as the intersection of future and past directed light-cones) is that of double light-cone (double pyramid) and this must relate closely to the problem at hand. An easy manner to obtain absolute arrow of geometric time at least statistically is to assume that embedding space is $M^4 + \times CP_2$ - that is product of future like cone with CP_2 . The problem is however that of finding a convincing quantal mechanism generating the arrow of time, and also explaining why the geometric arrow of time sometimes changes from the standard one (say for phase conjugate laser beams).

The latest vision about the generation of the arrow of geometric time the level of embedding space and space-time discussed in previous section involves rather radical features but is consistent with the second law if generalized so that the geometric arrow of time at the level of embedding level alternates as state function reduction takes place alternately at opposite light-like boundaries of a fixed CD. If the partially non-deterministic dynamics at space-time level defines a correlate for the dissipative dynamics of quantum jumps, the arrow of geometric time level at space-time level is constant (space-time surface can assignable to the state function reductions can be seen as folded surface spanned between boundaries of CD) and entropy defines monotonically increasing time coordinate. This is rather radical revision of the standard view but makes definite predictions: in particular syntropic aspects of the physics of living matter [J92] could be assigned with the non-standard direction of geometric time at the space-time level.

This approach however still suffers from a defect. CDs are regarded as completely non-dynamical: once CD is created it remains the same from quantum jump to quantum jump and thus serves as a fixed arena of dynamics. This cannot be the case.

Some questions about CDs and their quantum dynamics

One can raise several questions relating to CDs.

1. CDs are assumed to form a fractal hierarchy of CDs within CDs. The size scale of CD has been argued to come as an integer multiple of CP_2 size scale on basis of number theoretic arguments. One can ask whether CDs can overlap and interact and what interaction means.
2. What is the proper interpretation of CD? Could CD correspond to a spotlight of consciousness directed to a particular region of space-time surface, so that space-time surface need not end

at the boundaries of CD as also generalized Feynman diagrammatics mildly suggests? Or do the space-time surfaces end at the boundaries of CD so that CD defines a sub-Universe?

3. Should one assign CD to every subsystem - even elementary particles and fermion serving as their building bricks? Can one identify CD as a carrier of topologically quantized classical fields associated with a particle?

As already noticed the picture based on static CDs is too simplistic. This inspires several questions relating to the possible dynamics of CDs.

1. In ZEO one can in principle imagine a creation of CD from and its disappearance to vacuum. It is still unclear whether the space-time sheets associated with CD restricted to the interior of CD or whether they can continue outside CD.

For the first option appearance of CD would be a creation of sub-Universe contained by CD. CD could be assigned with any sub-system. For the latter option the appearance of CD would be a generation of spotlight of consciousness directing attention to a particular region of embedding space and thus to the portions of space-time surfaces inside it. Quantum superposition of space-time surfaces is actually in question and should be determined before the presence of CD by vacuum functional. How to describe possible creation and disappearance of CDs quantally, is not clear. For instance, what is the amplitude for the appearance of a new CD from vacuum in given quantum jump?

2. CDs have various moduli and one could assign to them quantum dynamics. The position of cm or either tip of CD in M^4 defines moduli as does also the point of CP_2 defining the origin of complex Eguchi-Hanson coordinates in which $U(2) \subset SU(3)$ acts linearly: these points are in general assumed to be different at the two ends of CD. If either tip of CD is fixed the Lorentz boost leaving the tip fixed, moves the other along constant proper time hyperboloid H^3 and the tessellations defined by the factor space H^3/Γ , where Γ is discrete subgroup of $SL(2, C)$, are favored for number theoretical reasons.

Quantum classical correspondence inspires the question whether the boost is determined completely by the four-momentum assignable to the positive/negative energy part of zero energy states and corresponds to the four-velocity β defined by the ratio P/M of total four-momentum and mass for the CD in question. It seems that this kind of assumption can be justified only in semiclassical approximation.

3. In ZEO cm degrees of freedom of CD cannot carry Poincare charges. One can however assign the Poincare charges of the positive energy part of zero energy state to a wave function depending on the coordinate differences m_{12} defining the relative coordinate for the tips of the CD.

The most general option is that the size scale of CD is continuous. This would allow to realize momentum eigen state as the analogs of plane waves as a function of the position m_{12} of the (say) upper tip of CD relative to the lower tip.

The size scale of CD has been however assumed to be quantized. That is, the temporal distance T between the tips comes as an integer multiple of CP_2 time T_{CP_2} : this scale is about 10^4 Planck lengths so that this discretization has not practical consequences. Discretization is suggested both by the number theoretical vision, the finite measurement resolution, and by the general features of the U-matrix expressible in terms of S-matrix and hermitian square roots of density matrices forming orthonormal basis. U-matrix relates M-matrices associated with CDs with different size scales, which correspond to the Lorentz invariant temporal distance $T_n = nT_{CP_2}$ between the tips. The scaling up of the temporal distance would represent scaling of CD in the rest system defined by the fixed tip thus translating the second tip with integer multiple of T_{CP_2} from T_{n_1} to T_{n_2} .

A further quantization would relate to the tessellations defined by the subgroups Γ . The counterparts of plane waves for the momentum eigenstates would be defined in a discretized version of Minkowski space obtained by dividing it to a sequence of discretized hyperboloids with proper time distance $a = nT_{CP_2}$ from the lower tip of CD.

4. There is evidence that one can assign a CDs with a fixed size scale to a given particle as secondary p-adic length scale: for electron this size scale would correspond to Mersenne prime M_{127} and frequency 10 Hz defining a fundamental biorhythm. This would give a deep connection between elementary particle physics and physics in macroscopic length scales. The integer multiples of the secondary p-adic length size scale would correspond to integer values of the effective Planck constant.

A natural interpretation of this scale would be as infrared cutoff so that the wave functions approximating momentum eigenstates and depending on the relative coordinate m_{12} would be restricted in the region between light-cone boundary and hyperboloid $a = M_{127}T_0$. Similar restriction would take place for all elementary particles. For particle with effective Planck constant $\hbar_{eff} = n\hbar_0$ the IR cutoff would be n -multiple of that defined by the secondary p-adic time scale.

Could CDs allow to understand the simultaneous wave-particle nature of quantum states?

One of the paradoxical features of quantum theory is that we observe always particles - even with well-defined momentum - to have rather well-defined spatial orbits. As if spatial localization would occur in quantum measurements always and would be a key element of perception and state function reduction process. This raises a heretic question: could it be possible that the localized particles in some sense have a well-defined momentum. In standard quantum theory this is definitely not possible. The assignment of CD with particle - or any physical system - however suggests that this paradoxical looking assignment is possible. Particle would be localized with respect to (say) the lower tip of CD and de-localized with respect to (say) the upper tip and localization of the lower tip would imply de-localization of the upper tip.

It is indeed natural to assume that either tip of CD - say lower one - is localized in M^4 in state function reduction. Unless one is willing to make additional assumptions, this implies not only the non-prepared character of the state at the upper tip, but also a de-localization of the upper tip itself by non-triviality of M-matrix: one has quantum superpositions of worlds characterized CDs with fixed lower tip. The localization at the lower tip would correspond to the fact that we experience the world as classical. Each zero energy state would be prepared at the either (say lower) end of CD so that its lower tip would have a fixed position in M^4 . The unprepared upper tip could have a wave function in the space of all possible CDs with a fixed lower tip.

One could also assign the spinor harmonics of $M^4 \times CP_2$ to the relative coordinates m_{12} and their analogs in CP_2 degrees of freedom. The notion of CD would therefore make possible to realize simultaneously the particle behavior in position space (localization of the lower tip of CD) and wave like nature of the state (superposition of momentum eigenstates for the upper tip relative to the lower tip).

This vision is only a heuristic guess. One should demonstrate that the average dynamical behavior for coordinate differences m_{12} corresponds to that for a free particle with given four-momentum for a given CD and fixed quantum numbers for the positive energy part of the state.

The arrow of geometric time at the level of embedding space and CDs

In the earlier argument the arrow of geometric time at embedding space level was argued to relate to the fact that zero energy states are prepared only at the either end of CD but not both. This is certainly part of the story but something more concrete would be needed. In any case, the experienced flow of time should relate to what happens CDs but in the proposed model CDs are not affected in the quantum jump. This would leave only the drifting of sub-CDs as a mechanism generating the arrow of geometric time at embedding space level. It is however difficult to concretize this option.

Could one understand the arrow of geometric time at embedding space level as an increase of the size of the size of CDs appearing in zero energy state? The moduli space of CDs with a fixed upper/lower tip is without discretization future/past light-cone. Therefore there is more room in the future than in past for a particular CD and the situation is like diffusion in future light-cone meaning that the temporal distance from the tip is bound to increase in statistical sense. This

means gradual scaling up of the size of the CD. A natural interpretation would be in terms of cosmological expansion.

There are two options to consider depending on whether the embedding space is $M^4 \times CP_2$ or $M_+^4 \times CP_2$. The latter option allows local Poincare symmetry and is consistent with standard Robertson-Walker cosmology so that it cannot be excluded. The first option leads to Russian doll cosmology containing cosmologies within cosmologies in ZEO and is aesthetically more pleasing.

1. Consider first the $M^4 \times CP_2$ option. At each tip of CD one has arrow of geometric time at the level of embedding space and these arrows are opposite. What does this mean? Do the tips correspond to separate conscious entities becoming conscious alternately in state function reductions? Or do they correspond to a single conscious entity with memories?

Could sleep awake cycle correspond to a sequence of state function reductions at opposite ends of personal CD? It would seem that we are conscious (in the sense we understand consciousness) only after state function reduction. Could we be conscious and have sensory percepts about the other end of CD during sleep state but have no memories about this period so that we would be living double life without knowing it? Does the unprepared and de-localized part (with respect to m_{12}) of zero energy state contribute to the conscious experience accompanying state function reduction? Holography would suggest that this is not the case.

If CD corresponds to a spotlight of consciousness, the time span of conscious experience could increase in both time directions for the latter option. The span of human collective consciousness has been increasing in both direction all the time; we are already becoming conscious what has probably happened immediately after the Big Bang. Could this evolution be completely universal and coded to the fundamental physics?

2. If the embedding space is assumed to be $M_+^4 \times CP_2$, one obtains only one arrow of time in the long run. The reason is that the lower tip of any CD sooner or later reaches $\delta M_+^4 \times CP_2$ and further expansion in this direction becomes impossible so that only the expansion of CD to the future direction becomes possible.

Summary

The proposed vision for the dynamics of the moduli of CDs is rather general and allows a concrete understanding of the arrow of geometric time at embedding space level and binds it directly to expansion of CDs as analog of cosmic expansion. The previous vision about how the arrow of geometric time could emerge at the level of space-time level remains essentially un-changed and allows the increase of syntropy [J92] to be understood as the increase of entropy but for a non-standard correspondence between the arrows of subjective time and the arrow of embedding space time.

Embedding space spinor harmonics characterizing the ground states of the representations of symplectic group of $\delta M_+^4 \times CP_2$ define the counterparts of single particle wave functions assignable to the relative coordinates of the second tip of CD with respect to the one fixed in state function reduction. The surprising outcome is the possibility to understand the paradoxical aspects of wave-particle duality in terms of bi-local character of CD: localization of given tip implies de-localization of the other tip.

5.4.5 The Arrow Of Geometric Time And The Arrow Of Logical Implication

If physics is mathematics in the sense that there is nothing behind quantum states regarded as purely mathematical objects, Boolean logic must have a direct manifestation in the structure of physical states. Physical states should represent quantal Boolean statements which get their meaning via quantum jumps. In TGD framework WCW ("world of classical worlds") spinor fields represent quantum states of the Universe and WCW spinors correspond to fermionic Fock states for second quantized induced spinor fields at space-time surface. Fock state basis has interpretation in terms of Boolean algebra. In positive energy ontology the problem is that fermion number as a

super-selection rule would allow very limited number of Boolean statements to be represented. In ZEO the situation changes.

The fermionic parts of positive and negative energy parts can be seen as quantum superpositions of Boolean statements with fermion number in given mode (equal to 0 or 1) representing yes/no or true/false. Also various spin like quantum numbers associated with oscillator operators have same interpretation. Zero energy state could be seen as quantum superposition of pairs of elements of Boolean algebras associated with positive and negative energy parts of the zero energy state.

The first - and incorrect - interpretation is that zero energy state represents a quantum superposition of equivalent statements $a \leftrightarrow b$ and thus abstraction $A \leftrightarrow B$ involving several instances of A and B . The breaking of time reversal invariance allowing localization to definite fermionic quantum numbers at single end of CD only however implies that quantum states can only represent abstraction of logical implication to $A \rightarrow B$ rather than equivalence. p-Adic physics for various primes p could represent correlates for cognition and intentionality.

5.4.6 The Roles Of Sensory Perception And Motor Action In TGD Framework

The attempts to define consciousness rely on two basic approaches. The first approach emphasizes direct sensory awareness and formation of cognitive representations from it (phenomenal consciousness and reflective consciousness). Second approach emphasizes volition, motor plans, and motor actions.

The analogs of sensory representations and motor actions emerge at the fundamental level in quantum TGD without mentioning anything about brain. In ZEO state function reduction is replaced with a cascade of state function reductions corresponding to various scales for CDs forming a fractal hierarchy. State function reduction can take place to either of the opposite boundaries of CD in a given length scale. The reduction at given boundary of CD would always force de-localization of the opposite boundary of CD creating quantum superposition of CDs with various sizes. Also new sub-CDs (correlates for sensory mental images) within the resulting bigger CDs are naturally generated. This would explain the arrow of geometric time at embedding space level but the arrows are opposite at the opposite boundaries of CD.

The reduction to opposite boundaries of CD gives rise to zero energy states related by time reversal at the level of embedding space. If “my” conscious experience corresponds to reductions to either “upper” or “lower” boundary of CD of wake-up cycle defining me, I will experience that the arrow of geometric at the level of embedding space arrow is constant and would be basically due to the scaling up of the average size of “personal” CD. “Upper” “lower” can be fixed by the arrow of time assignable to large enough CD defining environment.

Standard quantum measurement theory assumes that a state function reduction followed immediately by a new one does not affect the reduced state [this gives rise to so called quantum Zeno effect: quantum monitoring of unstable particle prevents its decay (watched kettle does not boil)]. That repeated state function reduction at given boundary of CD does not affect the part of zero energy state at that boundary resulting in the reduction for given CD would generalize this hypothesis. Note that the parts of zero energy states at the opposite boundary are affected: in particular, the size scale of CD increases.

If this assumption hold true, the subsequent reductions at the same boundary of CD would effectively correspond to single reduction at the passive boundary of CD, and one would effectively have an alternating sequence of cascades of state function reductions beginning from opposite boundaries of CDs. Note however that there a fractal cascade of reductions beginning from sub-CDs the CD is assumed changing the state in smaller scales.

In TGD framework the counterpart of quantum Zeno effect would be achieved by closing an unstable particle inside small enough CD so that the unitary time evolution restricted to CD would not affect the particle appreciably and state function reductions at boundaries of this CD very rarely would give rise to a final state of decay. Watchdog in this case would be the self to which this CD corresponds to.

Motor action as time reversal of sensory perception

In TGD framework motor action could be seen as a time reversal of sensory perception so that sensory-motor pairing could be seen as fundamental element of all conscious existence. This symmetry is very profound and strong prediction and forces to modify dramatically the beliefs about the arrow of geometric time and its relation to the subjective arrow of time. The variation of the arrow of time would be basic feature of living matter.

Just to fix conventions let us fix arrow of time as the arrow of the embedding space time for a very large CD, maybe of cosmic size scale, so that there is unique time direction corresponding to future.

1. All scales for CDs are possible. For sub-CDs of given CD the experiences associated with sub-CD define mental images of CD and the experience can be assigned with either boundary of sub-CD. Let us tentatively agree that for a given CD “lower” and “upper” boundaries are in future and past when seen from the center point of CD (past and future could be permuted in the convention).

This choice would conform with the interpretation that motor “me” I_m makes a fuzzy prediction of future as superposition of space-time sheets extending from the lower boundary of CD and sensory “me” I_s generates memories represented by superposition of space-time sheets extending downwards from the upper boundary of CD. I do not quite have the courage to completely exclude the second option in which the roles of motor me and sensory me are changed.

2. With this assumption one can assign to a sub-CD near upper *resp.* lower boundary of sub-CD sensory mental images *resp.* their time reversals. In the interior they would represent memories *resp.* predictions. The larger CD would experience these sub-selves as mental images and interpret them in terms of ordinary sensory percepts *resp.* volitions, decisions, and plans. The primary sensory experience, phenomenal experience, involves generation of negentropic entanglement as the sensory mental image combines as a tensor factor with the existing sequence of mental images forming a sensory representation defining memory. The reading of this sequence of mental images using interaction free quantum measurement gives rise to a conscious memory about the mental image sequence.
3. A prediction, which looks rather strange at first glance, follows. “My” CD would be seat for two selves having their own phenomenal experiences seated at the opposite boundaries of my CD. They would be sensory me I_s assignable to sensory perception and motor me I_m assignable to motor action as time reversed sensory perception and assignable to the opposite boundaries of CD when they are localized in state function reduction. The time reversed sensory percept is interpreted in terms of predictions, volitions, and plans at least by larger CD having the CD as sub-CD. Sensory and motor “mes” would appear in all scales in the hierarchy of sub-CDs.
4. Since the scale of CDs increases quantum jump by quantum jump on the average and new sub-CDs emerge, the size scale of the largest CD in hierarchy increases and the perceptual fields of the two “me” s associated with it shift towards geometric future *resp.* past of the embedding space. The sub-CDs near the boundaries of largest CD give rise to sensory percepts of the two “me” s involved with the largest CD in the hierarchy. Those in the interior define memories. The flow of time would correspond to the gradual shifting of the upper/lower boundary of largest CD to future/past and generation of sensory mental images (sub-CDs) near the boundary. Same would of course occur for the smaller CDs. The time interval about which memories are about and also the time scale for predictions of future increases since the size of the personal CD is gradually scaled up.

Quantitative considerations

One can make also quantitative questions.

1. What is the average increase of the temporal distance between the tips of CD in a pair of state function reductions to opposite boundaries defining the chronon of subjective experience? The duration of this chronon can depend on the level of the self hierarchy.

For human sensory consciousness this chronon would naturally correspond to the time scale of about .1 seconds having interpretation as a duration of sensory mental image. Each pair of state function reductions would generate a layer of the sensory mental images at the lower and upper boundary of “our” CD.

This leaves open the size scale of “our” CD and lifetime would represent only the size scale for the increase of “our” CD during life cycle. This would mean that the durations of consciousness for the two “me” s assignable to “our” CD would be measured using .1 second as a natural unit.

2. What can one say about the size scales of CDs themselves? Since the memories are about the time interval, which is roughly the duration of life cycle at most, the first guess is that the size of personal CD is of the order of duration of life cycle. By the previous argument however only the increase of the distance between the tips of “personal” CD naturally corresponds to the duration of life cycle so that the size scale of personal CD could be much larger. Note that the conscious experiences of I_s and I_m assignable to sensory percepts and motor actions should correspond to sub-CD: s with size scale not much larger than .1 seconds. This is consistent with the interpretation of sensory percepts of I_m as plans, decisions, predictions, and volitions. The sub-CDs with time scale of say years are however possible and would correspond to memories and plans in time scales of years.
3. One can imagine also a fractal hierarchy for the increments ΔT_i of the temporal distance T_i between tips of CDs assignable to single pair of quantum jumps to opposite boundaries of CD in given length scale. $\Delta T = .1$ seconds would not be the only possible duration of chronon. This time scale is however very special since it corresponds to the Mersenne prime M_{127} assignable to electron which corresponds to largest Mersenne prime which does not correspond to completely super-astrophysical p-adic length scale. The smaller Mersenne primes - such as M_{107} and M_{89} could correspond to shorter time scales perhaps assignable to nerve pulse in the case of lightest quarks. All primes characterizing elementary particles could define chronons of this kind serving as clocks. The hierarchy of chronons could mean sensory percepts and motor actions have a fractal hierarchy of resolutions identifiable as kind of abstraction hierarchy.

The clocks defined by these chronons of duration T_i should be synchronized in the sense that there would $N_{ij} = \Delta T_i / \Delta T_j$ quantum jumps with time increment T_j per single quantum jump with time increment T_i .

Could various periodic phenomena such as diurnal period of 24 hours defining sleep-awake cycle, annual cycle, and various bio-rhythms such as EEG rhythms, define also chronons? Could cyclicity which seems to appear at the level of sensory and cognitive mental images relate to this kind of chronons: for instance, after images are a good example about mental images having analog of wake-up-sleep cycle.

Questions

There are also questions about the relation to the functioning of brain.

1. How sleep-awake cycle relates to this picture? The above argument suggest that .1 second time scale rather than 24 hour time scale defines the increase of CD scale assignable to single pair of state function reduction assignable to “me”. Therefore the period assignable to single moment of human sensory conscious of the two “me” s would be of order .1 seconds.

This strongly suggests that due to the lack of sensory input and absence of motor actions we are conscious during sleep but do not have memories from this period. Dreams generated by virtual sensory input to retina would produce memories during sleep state. Revonsuo indeed mentions that according to the reports of subject persons after awakenings sleeping period seems to involve either dreams or sleep mentation. Sleep mentation is very simple during nREM sleep: for instance, repetition of some word of internal speech. Sleep mentation would involve motor actions generating internal speech and in some cases also genuine speech. Also genuine motor actions such as sleep walking are possible.

2. Could the sensory-motor dichotomy have some relation to the right-left dichotomy at the level of brain? Right and left brain hemisphere could naturally correspond to parallel CDs of same size scale. Could right and left brain (or parts of them) organize their wake-up periods as in shift work: if left brain hemisphere is awake right hemisphere sleeps (sensorily perceives the opposite end of its CD) and vice versa, an alternating dominance by either hemisphere results, and one could understand sensory rivalry. The time scale of CDs possibly involved would be much shorter than that of sleep-awake cycle in this case. Interestingly, the duration of hemisphere dominance period in some disorders like schizophrenia is anomalously long.

The CD containing both these CDs - "entire brain CD" - would be also present. The view of "brain CD" about world represented by entangled right and left negentropic mental images would be analogous to initial and final state and thus contain much more information than given by either right or left hemisphere. In the case of visual mental images this would give rise to stereo vision.

Could this shift work between parts of right and left hemisphere be realized in several time scales of CDs? Even in the scale corresponding to sleep-awake rhythm? It is known that in case of some birds and mammals, which must be motorially and sensorily active all the time, the brain hemispheres have this kind of shift work in long time scale.

5.4.7 Trying To Understand The Relationship Between Subjective And Geometric Time

I am trying to improve my understanding about the relationship between subjective and geometric time. Subjective time corresponds to a sequence of quantum jumps at given level of hierarchy of selves having as correlates causal diamonds (CDs). Geometric time is fourth space-time coordinate and has real and p-adic variants. This raises several questions.

1. How the subjective times at various levels of hierarchy relate to each other? Should/could one somehow map sequences of quantum jumps at various levels to real or p-adic time values in order to compare them - as quantum classical correspondence indeed suggests?
2. Subjective existence corresponds to a sequence of *moments of consciousness*: state function reductions at opposite boundaries of CDs. State function reduction reduction localizes either boundary but the second boundary is in a quantum superposition of several locations and size scales for CD.

There are two obvious problems related to the time experience.

- (a) If state function reductions occur alternately- one at time- then it is very difficult to understand why we experience same arrow of time continually: why not continual flip-flop at the level of perceptions. Some people claim to have actually experienced a temporary change of the arrow of time: I belong to them and I can tell that the experience is frightening. Why we experience the arrow of time as constant?

One possible way to solve this problem - perhaps the simplest one - is that state function reduction to the same boundary of CD can occur many times repeatedly. This solution is so absolutely trivial that I could perhaps use this triviality to defend myself for not realizing it immediately! I made this totally trivial observation only after only after I had realized that also in this process the wave function in the moduli space of CDs could change in these reductions. Zeno effect in ordinary measurement theory relies on the possibility of repeated state function reductions. In the ordinary quantum measurement theory repeated state function reductions don't affect the state in this kind of sequence but in ZEO the wave function in the moduli space labelling different CDs with the same boundary could change in each quantum jump. It would be natural that this sequence of quantum jumps give rise to the experience about flow of time? This option would allow the size scale of CD associated with human consciousness be rather short, say, 1 seconds. It would also allow to understand why we do not observe continual change of arrow of time. Maybe living systems are working hard to keep the personal arrow of time changed and that it would be extremely difficult to live against the collective arrow of time.

- (b) We experience time as a continuous flow rather than sequence of discrete jumps. Is this a problem or not? One could argue that it is not possible to be conscious about being unconscious so that gaps would not be experienced. But is this so simple? We are indeed able to experience the gap in sensory consciousness caused by sleeping over night (this does not mean we have been unconscious: we just do not remember).
3. Subjective time is certainly not metricizable whereas geometric time is and defines a continuum. But are moments of consciousness well-ordered as the values of real variant of geometric time are? This relates closely to the relationship of subjective time to geometric time. Certainly subjective time does not allow any continuous measure in real sense as geometric time does. One can however map moments of consciousness to integers.
- (a) It would seem natural to be able to say about two moments of consciousness - call them A and B, - whether A is before B or vice versa. Moments of consciousness would be well-ordered and could be mapped to *real* integers. But is this the case always? There is experimental evidence for the fact that consciously experience time ordering does not always correspond to the physical one. This was observed already by Libet (see <http://tinyurl.com/yathqkzv>) for my first attempt to understand these findings [K136]).
 - (b) What about p-adic integers as labels for moments of consciousness as suggested by the vision about p-adic space-time sheets as correlates for cognition. Given p-adic integers m and n , one can only say whether the p-adic norm of m is larger than, smaller than, or equal to that of n . One can say that p-adic integers are weakly ordered.

p-Adic integers form a continuum in p-adic topology. Could one map the infinite sequence of quantum jumps already occurred to p-adic integers and in this manner to p-adic continuum instead of real one? Could the p-adic cognitive representations allow to achieve this? If so, the experience about conscious flow of time could be due to the p-adic topology for cognitive representation for the sequence of quantum jumps!

Could p-adic integers label moments of consciousness and explain why we experience conscious flow of time?

Next arguments give a more precise formulation for the idea that p-adic integers might label the sequence of quantum jumps at the level of conscious experience, or rather reflective consciousness involving various representations realized as “Akashic records”: NMP and ZEO considerably modify the standard quantum measurement theory).

1. Most p-adic integers expressible as $n = \sum_k n_k p^k$ are infinite in real sense and in p-adic topology they form a continuum. Suppose that the infinite sequence of moments of consciousness that have already taken place can be labelled by p-adic integers and look what might be the outcome.
2. Sounds very strange in ears of real analyst but is true: the integers n and $n + kp^N$, for N large are very near to each other p-adically. In real sense they are very far. This allows to fill the gaps between say integers $n = 1$ and 2 by p-adic integers which are very large in real sense.
3. The p-adic correlate of the sequence of discrete quantum jumps/moments of consciousness would define p-adic continuum which in turn can be mapped to real continuum by canonical identification.

This map sequence of moments of consciousness to p-adic continuum would be nice but maybe tricky for any-one accustomed to think in terms of real topology!

This raises two questions.

1. p-Adic integers are not well-ordered. Could one induced the well-ordering of real time to p-adic context by mapping p-adic time axis to real one in a continuous manner and in this manner achieving mapping of moments of consciousness to real time axis?

2. Could canonical identification $\sum_k n_k p^k \rightarrow \sum_k n_k p^{-k}$ map (or its appropriate modification) allow to map p-adic integers to real numbers and in this manner induce real well ordering to the p-adic side. The problem is that real number with finite binary expansion has second infinite expansion ($1=.9999\dots$ is example using decimal expansion) so that two p-adic time values correspond to any real time value with finite binary digits. Should one restrict the consideration to integers with finite number of binary digits (finite measurement resolution) and select either branch? Could the two branches correspond to real time coordinates assignable to the opposite boundaries of CD defining two conscious selves in this scale?

What happens when I type letters in wrong order?

One can speak about sensory and cognitive orderings of events corresponding to reals and p-adics (for various values prime p or course). The cognitive ordering of events would not be well-ordering if cognition is p-adic. Is there any empirical support for this besides Libet's mysterious looking findings?

Maybe. For instance, as I am typing text I experience that I am typing the letters of the word in the correct order but now and then it happens that the order is changed, even the order of syllables and sometimes even that of short words can change. It is probably easy to cook up a very mundane explanation in terms of neuroscience or even electric circuits from keyboard to computer memory, or computer itself. One can however also ask whether this could reflect the fact that p-adic ordering of the intentions to type letter is not well-ordering and does not always correspond to the real number based order for what happened ?

In TGD Universe writing process involves a sequence of transformations of p-adically realized intention to type a letter to a real action (doing it). At space-time level it is therefore a map from p-adic realm to real realm by a variant of canonical identification crucial in the definition of p-adic manifold concept (see <http://tinyurl.com/ydxw3zvm>) assigning to real preferred extremal of Kähler action a p-adic preferred extremal in finite measurement resolution [K143]).

The variant of canonical identification in question defines chart maps from real to p-adic realm and vice versa, and is defined in such a manner that discrete and rationals in a finite subset of rationals are mapped to themselves and defining intersection of real and p-adic realms.

1. In the case of p-adic integers this subset is characterized by a cutoff telling the power of p below which p-adic integers and real integers correspond to each other as such. For the corresponding moments of consciousness (now intentions to type letter) one has same ordering in both realms. For integers containing higher powers of p a variant of canonical identification mapping p-adics to reals continuously is applied. In this case ordering anomalies can appear.
2. Another binary cutoff comes from physics: real preferred extremals are mapped to p-adic preferred extremals and vice versa: without the cutoff the p-adic image of real extremal would be continuous but non-differentiable so that field equations would not make sense. The cutoff tells the largest power of p up to which the variant of canonical identification is performed for p-adic integers. Also now ordering anomalies appear if one regards p-adic integers as ordinary integers.
3. For the remaining integers the map is obtained by completing the discrete set of points to a preferred extremal of Kähler action on both real and p-adic sides so that physics enters into the game. This assignment need not be unique and the most natural manner to handle the non-uniqueness is to form quantum superposition of all allowed completions with same amplitude: this effective gauge invariance would be very natural from the point of view of finite resolution and conforms with the vision about inclusions of hyper-finite factors (see <http://tinyurl.com/yaye9z3w>) as a representation for finite measurement resolution giving rise to the analog of dynamical gauge symmetry [K141].

Could the strange inconsistencies between cognitive (sequences of intentions) and sensory time orderings (sequence of typed letters) reflect the fact that the ordering of p-adic integers as real integers is not the same as the ordering of their real images under canonical identification? Could it be possible to test this and perhaps deduce the prime p characterizing p-adic topology of cognitive representation in question?

5.5 In What Sense The Flow Of Time Could Correspond To The Increase Of The Effective Planck Constant?

I like answering questions. It gives a lot of meaning to the life of a theoretician who is not allowed to enjoy the pleasures of academic existence. Career builder would of course argue that writing again and again similar answers is a waste of time: I should be building social networks to important people instead. This activity however allows to make important observations and little discoveries. This time I answered to the questions relating to non-determinism of Kähler action. How this non-determinism relates to quantum non-determinism? How the non-determinism in elementary particle scales relates to that in biology?

The unexpected fruit was a little might-be discovery: the mechanism generating the arrow of geometric time in zero energy ontology might rely in crucial manner to a sequence of phase transitions increasing the value of Planck constant $\hbar_{eff}/\hbar = n$ and hence the size of the causal diamond (CD) characterized by quantum average temporal distance. Since the second boundary of CD is fixed, the second one moves to future in average sense: hence the flow of experienced time and its arrow. Conscious entities become more intelligent as they age! It became also clear that large \hbar_{eff}/\hbar characterizes many-particle system rather than single particle. This leads to view in which intelligent consciousness involving the experienced about the flow of time emerges as the complexity of the systems measured by the number of fundamental particles increases.

The guess was wrong as such. It seems that the time evolution by repeated state function reductions leaving the state at passive boundary of CD invariant should correspond to localizations in the moduli space for causal diamonds with second boundary fixed. It cannot affect the value of \hbar_{eff} since this would scale up the size of CD and affect also the state at the passive boundary by scaling up the sizes of 3-surfaces.

Rather, this time evolution should be analogous to a sequences of time shifts: the time would be the integer valued proper time distance between the tips of CD and the operator acting on zero energy state would be exponent of energy. Each shift would be followed by a localization in the modular degrees of freedom of CD but no state function reduction would occur since this would change the arrow of time and opposite boundary of CD would become the passive boundary.

The scaling of \hbar_{eff} by integer would define the scaling of CD in the first state function reduction to the opposite boundary. This reduction would be preceded by a unitary time evolution defined by exponent of conformal scaling generator. Of course, this scaling could be also trivial! If one considers only these discrete moments of time one obtains a time evolution consisting of discrete time and it is kind of jumping forth and back with increasing amplitude. The repeated birth and death of mental image could corresponds to this kind of evolution at the level of conscious experience.

5.5.1 Background

Quantum classical correspondence suggests that the non-determinism of Kähler action could be correlated for quantum non-determinism. An alternative but not exclusive interpretation is as a correlate for quantum criticality.

The non-determinism of Kähler action and quantum non-determinism

The first question was about the relationship between non-determinism of preferred extremals and quantum non-determinism. As a matter of fact, I like to use the phrase “partial failure of determinism for Kähler action” rather than “non-determinism of Kähler action”.

A possible interpretation could be as a correlate for quantum non-determinism. Second interpretation would be in terms of quantum criticality implying non-determinism. I do not know whether the interpretations are actually equivalent.

I certainly do not believe that one could get rid of quantum non-determinism and there is no need for it. The generalisation of quantum-classical correspondence is however natural in ZEO, where basic objects are 4-D surfaces- classical time evolutions serving as space-time correlates for quantal evolutions.

The origin of the failure of classical determinism is following.

1. Kähler action has a huge vacuum degeneracy. For instance, for space-time surfaces, which are maps from M^4 to at most 2-D Lagrangian manifold of CP_2 having by definition vanishing induced Kähler form (configuration space and momentum space are Lagrangian manifolds in the context of classical mechanics) induced Kähler form of course vanishes. These vacuum extremals define an analog of gauge degeneracy of Maxwell action for vacuum extremals. For non-vacuum external it is expected to be lifted at least partially. Hence 4-dimensional spin glass degeneracy is more appropriate analogy. One could say that classical gravitation breaks the analog of gauge invariance for non-vacuum extremals.
2. For CP_2 type vacuum external one has also non-determinism, which corresponds directly to Virasoro conditions expressing the light-likeness of 1-D M^4 projection of the CP_2 type vacuum extremal. Now induced Kähler form does not vanish.
3. Zero energy ontology (ZEO) and causal diamond (CD) are essential notions concerning the interpretation but leave these notions as an exercise for the reader. The ends of the vacuum extremal at light-like boundaries of CD are connected by infinite number of vacuum extremals.

One expects that some of the vacuum degeneracy is present also non-vacuum external. Part of this degeneracy must be analogous to gauge degeneracy since by strong form of general coordinate invariance implying strong form of holography, only the partonic 2-surfaces and their 4-D tangent space data fix the physics since WCW metric depends only on this data. Hence the interiors of 3-surfaces carry very little information about quantum states.

Identification of gauge degeneracy as hierarchy of broken conformal gauge invariances

The conjecture is that conformal symmetries acting as partially broken gauge symmetries realize this vision. TGD allows several kinds of conformal symmetries, and a huge generalisation of string model conformal symmetries (including Kac-Moody) [K32] but I will not go to this here. Suffice it to say that the generalization of conformal symmetries means replacement of AdS/CFT correspondence with a correspondence which looks intuitively much more realistic [K115], [L33].

Classical conformal charges would vanish for sub-algebra for which the conformal weights are multiples of some integer n , $n = 1, 2, \dots$. These conditions would give the long-sought-for precise content to the notion of preferred extremal. These conditions would be the classical counterparts of corresponding quantum conditions and define a Bohr orbitology. This hierarchy would correspond to the hierarchy of Planck constants $h_{eff} = n \times h$ and to the hierarchy of dark matters [K47]. There would be infinite number of hierarchies $(1, n_1, n_2, \dots, n_i, \dots)$ such that n_i would divide n_{i+1} . They would correspond to the hierarchies of inclusions of hyper-finite factors of type II_1 (HFFs) [K141]. Included algebra defines measurement resolution, which would thus realized as generalized conformal gauge symmetries. Evolution would correspond to a sequence of symmetry breakings: this is not a new idea but emerges naturally if n serves as a quantum "IQ".

The proposal is that there is a finite number $n = h_{eff}/h$ of conformal equivalence classes of four-surfaces with fixed 3-D ends at the opposite boundaries of CD so that the non-determinism with gauge fixing would be finite and would correspond to the hierarchy of Planck constants and hierarchy of conformal symmetry breaking defined by the hierarchy of sub-algebras of various conformal algebras with weights coming as integer multiples of integer $n = 1, 2, \dots$. These n surfaces would be analogous to Gribov copies for gauge conditions in non-Abelian gauge theories.

5.5.2 The Non-Determinisms Of Particle Physics And Biology

There was also a question about the non-determinism of particle physics contra that of biology, where it manifests itself as partially free will.

NMP

Before continuing it is good make clear that a new principle is involved: Negentropy Maximization Principle (NMP) [K73]. Also a new kind of entanglement entropy based p-adic norm is involved. This entanglement entropy is negative unlike ordinary entanglement entropy and characterizes

two-particle system rather than single particle system. By consistency with quantum measurement theory it corresponds to identical entanglement probabilities $p_i = 1/n$.

Negentropic entanglement is assumed to be associated with pairs of n -sheeted coverings (at least these) defined by the space-time surfaces in n conformal equivalence classes associated with $n = h_{eff}/h$ and connecting same 3-surfaces at the ends of space-time surface. Two systems of this kind can entangle negentropically. The entanglement matrix associated with quantum computation proportional to a unitary matrix gives rise to negentropic entanglement. Also n -partite negentropic entanglement makes sense. Note that for hyper-finite factors of type II_1 the entanglement matrix is strictly unitary.

What could be common for particle physics and biology?

Basically the non-determinism of particle physics and of biology could be essentially the same thing but for living matter whose behavior is dictated by dark matter the value of $h_{eff}/h = n$ would be large and make possible macroscopic quantum coherence in spatio-temporal scales, which are longer by factor n . Note that n could characterize macroscopic quantum phase rather than single particle system: this distinction is important as will be found.

The hierarchy of CDs brings additional spatio-temporal scale identified as secondary p -adic scale characterising the minimal size of CD. This size scales like $h_{eff}/h = n$ and one can think of a superposition of CDs with different values of n and that the average value of n measuring the age of self increases during the sequence of quantum jumps. Since n is kind of IQ, NMP says that conscious entities should become wiser as they get older: maybe this is too optimistic hypothesis in the case of human kind but maybe electrons are different! I swear that this interpretation is not due to the fact that I have passed the magic threshold of 60 years when one begins to feel that the ageing means growing wisdom. I must confess that the interpretation of experience time flow in terms of increasing h_{eff}/h characterizing CD scaling has not come into my mind earlier. One could even consider the possibility that there is no superposition - just a sequence of h_{eff}/h increasing (in average sense) phase transitions, kind of spiritual growth even at the level of elementary particles - or rather, the macroscopic quantum phases.

For instance, for electron characterised by Mersenne prime $M_{127} = 2^{127} - 1$ the minimal CD time scale is .1 seconds (note that it defines a fundamental biorhythm of 10 Hz) and thus macrotemporal. Corresponding size scale is of the order of Earth circumference. This size scale could characterize quite generally the magnetic body of the elementary particle or the magnetic body at which macroscopic quantum phase of particles resides. In both cases there would be a direct connection between elementary particle physics and macroscopic physics becoming manifest in living matter via alpha rhythm for instance.

What distinguishes between particle physics and biology?

There are essential differences between elementary particle physics and biology. The first difference comes from quantum measurement theory in ZEO.

1. The repeated state function reduction does nothing for the state in standard ontology. In TGD the state is invariant only at the second boundary at which the reduction occurs. For second boundary of CD the average value of n increases. This gives rise to the experienced flow of geometric time and the arrow of time. Self exists as long as reductions take place on same boundary of CD and dies as the first reduction to opposite boundary is forced by NMP.
2. In particle physics context one expects that the duration of self identified as a sequence of state function reductions at the same boundary of CD is much shorter than in living matter. Otherwise one would have too strong breaking of reversibility in elementary particle time scales. One could also argue that for visible matter the value of h_{eff} should not change in the first state function reduction to the opposite boundary.

Here one must be very cautious. The flux tubes connecting the wormhole contacts serving as building bricks of the elementary particle could have very large h_{eff} having the p -adic prime characterizing the elementary particle as a factor and that the dynamics of elementary particles corresponds to the ordinary value of Planck constant as long as this flux tube is not involved. If the flux tubes mediate gravitational interaction scaling the size of the

gravitational bound state from the naïvely expected Planck scale to Compton length, the effects on other particle interactions would be negligible as gravitational interactions.

Objections usually help to make the formulations more precise. Now the objection is that the increase of average h_{eff}/h so that particles darken gradually, should have been observed long time ago since reaction rates are independent of Planck constant only the lowest order in h_{eff} that is in classical approximation. The attempt to circumvent this objection leads to two crucial questions?

1. Does h_{eff} characterize elementary particle (or fundamental fermion) or a magnetic/field body of physical system which could be also many-particle system.

If $h_{eff}/h = n$ corresponds to n -sheeted covering which becomes singular at the ends of space-time surface so that sheets coincide at partonic 2-surfaces representing particles, it seems that large h_{eff} is a phenomenon assignable to the field/magnetic body inside CD rather than particle identified as partonic 2-surface or 3-surface at the end of CD. If so large h_{eff} effects would relate to the dynamics associated with the magnetic/field bodies carrying dark matter.

2. Is darkness single particle phenomenon or many-particle phenomenon? For the latter option elementary particle physics would not be any challenge so that it looks the reasonable option. Note that negentropic entanglement requires at least one pair of (say) electrons and suggests macroscopic quantum phase - say high- T_c super-conductivity or super-fluidity.

The idea about evolution of many-electron systems at dark magnetic body generating increasing value of h_{eff} makes sense, and would conform with the observation that electrons secondary p-adic time scale defines fundamental bio-rhythm. Dark magnetic bodies carrying dark particles are indeed in key role TGD inspired quantum biology. Bose-Einstein condensates and spontaneously magnetized dark phases at magnetic bodies would conform with the idea that dark matter is many-particle phenomenon.

Large h_{eff} would not be seen in elementary particle physics. This does not seem to support the idea that sparticles in TGD SUSY might have same p-adic mass scale as particles but be more stable in dark phase (this would be due to the scaling up of the size of CD) [K109]. Note however that in TGD already elementary particles are many-fermion systems so that it might be possible to circumvent this objection.

3. The original formulation for darkness was at single particle level so that h_{eff} characterizes elementary particles rather than many-particle systems. In elementary particle reactions the particles in the same vertex would always have the same value of h_{eff}/h . It was assumed that h_{eff} can change only in 2-vertex analogous to mass insertion vertex.

The previous arguments suggest that darkness makes sense only for many-particle systems so that mass insertion vertex becomes phase transition. These phase transitions would occur routinely in living matter but as phase transitions involving large number of particles. For instance, bio-photons would result from dark photons in this manner. This picture seems to make sense at least at the level of many-particle systems but not necessary for Feynman graphs.

This many-particle aspect would explain at very general level why the search for dark particles has been fruitless.

Could one regard elementary particle as a conscious entity?

The previous considerations support the view that it is macroscopic quantum phases of particles at magnetic flux tubes which can be seen as conscious and intelligent evolving entities experience the flow of time. In the case of single elementary particle previous arguments would suggest that only single state function reduction occurs at given boundary of CD so that the lifetime of elementary particle self would have zero duration! This in accordance with the absence of the arrow of time at elementary particle level. Strictly speaking this does not exclude consciousness but excludes intelligence and experience of time flow.

Could already systems with small particle number, be conscious entities and develop - not necessarily large - $h_{eff}/h > 1$. Hadrons consist of quarks and I have considered the possibility that valence quarks and gluons at the color magnetic body are dark. Also nuclei as many-nucleon systems could be dark. In TGD even elementary particles consist of fundamental fermions so that one can ask whether elementary particles possess some elementary aspects of consciousness identified as the possibility of non-vanishing "biological" life-time. This kind of picture would conform with the idea about consciousness as something emerging as the complexity of the system increases.

The average lifetime of elementary particle as a conscious entity cannot be longer than the life-time of particle in the sense of particle physics. In the case of electron having infinite lifetime as elementary particle the "biological" lifetime must be finite since otherwise the irreversibility would manifest itself as a breaking of time reversal invariance in electron scale. The temporal time scale of CD characterising the dimensions of the magnetic body of the elementary particle is the first order of magnitude estimate for the lifetime of elementary particle self. The "biological death" of electron means state function reduction in the sense of ordinary quantum measurement theory implying for instance localization of electron or giving eigenstate of spin in given quantization direction and these quantum jumps meaning re-incarnations of electron certainly occur.

This time scale could give an idea about the geometric duration of elementary particle self (the growth of the temporal distance between tips of CD during the sequence of reductions or equivalently the increase of n). One expects that Δn is by NMP rather small for single particle systems.

Could thermodynamical breaking of time reversal symmetry relate to the CP/T breaking in particles physics?

Could the "thermodynamical" breaking of time reflection symmetry (T) correspond to the breaking of T as it is observed for elementary particles such as neutral kaon? I think that most colleagues tend to be skeptic about this kind of identification, and so do I.

The point is that particle physicist's T breaking could be purely geometric whereas thermodynamical breaking of T involves the notion of subjective time, state function reduction, and consciousness. One could however ask whether the particle physicist's T could serve as space-time correlate for thermodynamicist's T and whether systems showing CP breaking could be seen as conscious entities in very primitive sense of the word ($n_f/n_i > 1$ but small). An important point is that the time evolution for CDs corresponds to scaling so that usually exponential decay laws are replaced with their hyperbolic variants. Hyperbolic decay laws become an important signature of consciousness. For instance, bio-photon intensity decays in hyperbolic manner.

Consider neutral kaon as example.

1. The mean lifetimes are of long-lived and short lived neutral kaon are $\tau_L = 1.2 \times 10^{-8}$ seconds and $\tau_S = 8.9 \times 10^{-11}$ seconds: the ratio of the time scales is roughly 2^7 . This does not conform with the naïve guess that the size of CD gives estimate for the duration of elementary particle self (increase of the temporal distance between tips of CD): the estimate would be $\tau_L = 10^{-7}$ seconds from the fact that the mass of neutral kaon is roughly 10^3 times electron mass.
2. This is not too far from the lifetime of K_L^0 but is about 2^7 times longer than the life-time of short-lived kaon. Why K_S would be so short-lived? Could the lifetime be dictated by quark level: the longer time scale could be assigned as secondary p-adic time scale with the p-adic prime $p \simeq 2^k$, $k = 104$, characterising b quark. Could the short life-time be understood in terms of loops involving heavier quarks with shorter lifetimes as conscious entities: they indeed appear in the description of CP/T breaking?

5.6 Time For Time

I was very happy to find that Sean Carroll in Cosmic Variance (see <http://tinyurl.com/p9pvefz>) gave links to really interesting talks in Time conference arranged by fQXI. I have not been too happy for the elitistic nature of these conferences making impossible the communication of really new

theoretical ideas. By listening the brilliant talk [J38] by neuroscientist David Eagleman (see <http://tinyurl.com/credoxs>), I however learned that this conference made possible communication of extremely interesting experimental findings about the relation of the time of physicist to the subjective time. I sincerely hope that my colleagues would listen this talk and realize that there are fascinating problems to be solved. There is simply no theory and therefore no list of dead theories among which graduate student is allowed to choose as in theoretical physics.

Eagleman together with other neuro scientists make distinction between time and subjective time and the experimental work has revealed that this relationship looks very complex and is poorly understood. One of the key realizations forced by TGD inspired theory of consciousness - in a well-defined sense a generalization of quantum measurement theory - is that geometric time (the time of field equations) and subjective time (experienced time) are two different notions. The challenge is to understand how they relate and under what conditions and in what approximation their identification performed routinely my the naïve colleagues is possible. This was an excellent reason for continuing listening and I warmly recommend this for the reader. Also the other lectures might be equally rewarding. In the following I just represent TGD based interpretation of the findings and suggest that the reader would not take it too seriously and would try to build his or her own interpretation.

Eagleman talks about what he calls relativity of subjective time. This has of course nothing to do with the relativity of the geometric time. At the basic level subjective time need not even allow any metric measure (as is the case in TGD where subjective time corresponds to a sequence of quantum jumps).

5.6.1 Flash-Lag Effect And Its Modification

Eagleman tells first about very simple visual illusion known as flash-lag effect. One rotates a small circle around a circular orbit. As the circle passes the horizontal line there is a flash of light in the middle of the circle. If our perception were ideal the flash would be perceived in the middle of the circle. The circle is perceived to be 5 degrees ahead of the flash.

The first explanation to come in mind is that brain anticipates the motion of the flash and represent it to us in a position in which it would be in nearby future. Eagleman decided to test this proposal and studied three different situations. Two of them correspond to a circle rotating in opposite directions and the third one to a situation in which the circle stops at the position of the flash. The theory predicts that the circle is perceived to be ahead in all situations since the perceiver should not know anything about what happens in future. The surprise was that there was no flash-lag when the circle stopped. As if the brain would know what happens in the nearby future.

This kind of observation is not new. I remember more than a decade old experiment studying the galvanic response created by emotionally very provocative picture appearing as an odd-ball in a series of neutral pictures. This kind of response was observed. The mystery was that it was observed before the picture was seen! The result was of course not taken seriously by serious scientists. When a serious scientist associates something with the word “parapsychology” he loses totally ability to rational thinking and begins to rage.

The conclusion is that our moment of subjective time seems to have a finite duration about 80 ms and all events that occur in this time interval are associated with one and same moment of subjective time. This time interval would correspond to 12.5 Hz frequency. In TGD framework the interpretation could be in terms of the time scale assignable to causal diamond (CD) identified as intersection of future and past directed light-cones, which serves as embedding space-correlate for the moment of consciousness: this time would be the temporal distance between the tips of CD.

The fractal hierarchy of quantum jumps within quantum jumps (identifiable as with a hierarchy of selves withing selves) has the hierarchy of CDs as an embedding space correlate. For electron the time scale of CD is 100 seconds. What is troubling is that 80 ms corresponds to a time interval which is by 20 per cent shorter. One could of course assign this time scale to some cyclotron frequency in TGD framework but I would be very happy if it would correspond to a time duration of electron’s CD.

As Eagleman tells, perception involves gaps. For instance, during saccadic motion necessary for visual consciousness (the explanation in TGD framework is that the conscious experience is associated with nondeterministic change, quantum jump) visual system is not on. We do not

however perceive these gaps although we perceive the gaps created by putting lights off. Could it be that the gaps are absent because the 100 ms CDs in the sequences have overlap producing on the average 80 ms intervals without overlap? Could the absence of gaps also tell us that it is retina and various sensory organs which build the fundamental qualia and that brain only constructs a cognitive representation about it decomposing the world to objects with certain properties and names and also builds all kinds of useful associations? This picture applies to all sensory qualia in TGD Universe and one can circumvent various objections against it in terms of TGD view about time.

5.6.2 We Live In The Past: But In What Sense?

One surprising fact about consciousness is that we live in the past. The justification for this in terms of standard neuroscience, where brain builds both sensory and cognitive representations of the external world, does not require refined arguments.

Neural communications are extremely slow using light-velocity as the standard. The velocities of nerve pulses are between 1-100 m/s as compared with the light velocity 3×10^8 m/s. The communication of the sensory data to brain takes time which can be of order second. The data coming from various sensory organs with varying velocities must be processed and combined to single view about external world at associative cortex. This takes time since it is the slowest signalst that determine the time used for the processing. Eagleman gives a humorous example: tall people should live father in past than the short ones since it takes longer time for neural signals from feet to arrive from cortex to the brain! Different sensory inputs must be also combined together in a realistic manner.

Is the brain really able to meet this enormous challenge? The representation about the external world is not enough: this representation must be also realistic and 80 ms seems to represent the maximum duration of moment of sensory consciousness. Is the velocity of nerve pulses quite too slow to achieve this? And is information processing based on nerve pulse conduction really fast enough?

1. These questions could have been motivation for TGD proposal (or almost-prediction) that sensory organs are seats of primary sensory qualia experienced instantaneously.
2. They could have also motivated what proposal that quantum entanglement is needed to bind various parts of the body and brain to form single coherent conscious unit. Quantum entanglement makes possible effective signalling with infinite velocity. Of course, genuine signals are not in question. It is better to speak about macroscopic system behaving like an elementary particle. Dark matter realized as a hierarchy of macroscopic quantum phases with a larger value of Planck constant is what would make this possible.
3. Light velocity is ideal for the communication purposes in the scale of biological body. Could it be that biology might have been stupid enough to miss this kind of an opportunity? Could it be that neuroscientists are the stupid one and simply on a wrong track? In TGD inspired model dark photons with large value of \hbar (bio-photons would be dark photons transformed to ordinary photons) define a central element both in the communications from sensory organs to brain and to magnetic body and from magnetic body to biological body. At the level of body the communications would be practically instantaneous.
4. Even in Earth length scale the time taken by EEG photons to travel from biological body to the corresponding layear of the magnetic body would still be of order.1 seconds and the experiments of Libet demonstrate among other things that our sensory data is a fraction of second old. This has nothing to do with the conduction velocity of nerve pulses. The purpose of nerve pulses would be quite different: they would create fundamental memory representations and the model for this is based on DNA as topological quantum computer vision.

Explaining this would however require TGD based view about memory as 4-D perception: causal diamonds are 4-D objects and our conscious experience is always about 4-D space-time region. For sensory perception the scale of this region is.1 seconds. For the perceptions that

we call memories the scale is often years or even decades. Our conscious experience is 4-dimensional. Also our motor actions are essentially 4-dimensional: moment of consciousness replaces 4-D world (or quantum superpositions of them) with a new one: also our geometric past is changed in every moment of consciousness. This view resolves many puzzles related to memory but time is far from mature for the revolution. My hope is that the talks of Time conference could open the minds of at least some young colleagues.

5. The communications with light velocity make possible feedback from brain to sensory organs making possible the building of standardized mental images by using the virtual sensory input from brain to create a caricature. Our brain would be an artist using primary sensory input as a raw material.

5.6.3 Kublai Khan's Problem And Three More Surprises

Eagleman tells about the problem of emperor Kublai Khan. At that time people did not have internet and being a head of an empire of the size of Asia posed many problems. Kublai Khan used emissars travelling around the empire and bringing news about what happened. The problem was the correct integration of these data: the news about ending of some local war somewhere could arrive before the news telling that it had begun! Brain is faced with a similar problem. When the television came, one of the big problems was thought to be the synchronization of pictures and sound. It however turned out that brain takes care of this problem if the picture and sound to be associated with each other are within 80 milliseconds. The moment of subjective time has this duration.

That we live in past was the first surprise of neuroscience already discussed. Eagleman tells about three more big surprises of neuroscience.

Time perception recalibrates

The brain must build a logical story about sensory data coming through different sensory channels. To achieve this time perception recalibrates. When one comes from bright sunlight to a dim room, the response function of retina gets slower. This does not however happen at the level of conscious experience. A simple test is a sequence of button clicks causing a flash of light. Experimenter can cheat the subject person by producing the light flash with a delay. Surprisingly, the subject person notices nothing. What is even more surprising that when one adds to the sequence of click-flash pairs an odd-ball for which flash is not delayed, the flash is experienced to take place earlier than clicking! Again a direct evidence for the TGD prediction that our perceptive field is 4-dimensional.

In this kind of situation the natural conclusion of subject person would be that it was not me who did the click. Some other agent caused the flash whereas my own attempt fails. Eagleman suggests that schizophrenia might be a disorder of time perception. Person would attribute his own thoughts sometimes heard as internal voices to some external subjects since the time order is pathological. Maybe. What is known that schizophrenics have very sharp sensory perception which cannot be cheated and that there might be no re-calibration. Eagleman talks about temporal inflexibility. This is of course just a suggestion as Eagleman emphasizes. I am not enthusiastic about this kind of interpretation: the bicameral views of Jaynes fit much better with the idea that magnetic body uses biological body as sensory receptor and motor instrument.

Time is not one thing

Time perception is much more complex than one might think: it involves many aspects such as duration, simultaneity, flicker rate, time ordering. What brain does is the analysis of the sensory input, and its reconstruction from the resulting small pieces. This is very much what is done in the processing of the raw sound (and also pictures) in movies. This applies also to time perception. In TGD framework also the feedback from brain is essential and basic communications would take place using light. Nerve pulse patterns would serve quite different purpose and are also hopelessly slow for building the percept.

The rate of time flow correlates with the rate of neural metabolism

There is large number of findings supporting the few that the experienced rate for the flow of subjective time correlates with the rate of neural metabolism and therefore with the intensity of consciousness.

1. *Slowing down of the subjective time*

Slowing down of subjective time flow is familiar to anyone. This can happen in troublesome situation or in so called flow state. Interestingly, also in very boring situations (say waiting for someone to come) the same can happen. From my own experience I would say that the slowing down of subjective time characterizes very intense conscious experiences involving intense concentration. But why it would occur when you are bored: perhaps just because you are so intensely conscious about how boring your life is just now. You are not drowsy: you are impatient and irritated.

Various explanations have been proposed. The proposal that the slowing down of time is analogous to the slowing down of the magnetic tape reducing the frequencies of sounds fails. Another explanation could be in terms of increased time resolution and also I have proposed this explanation. This explanation was tested.

Eagleman did an experiment which could be also seen as a tongue-in-cheek variant of Galileo's famous experiment in which he dropped various objects from the tower of Pisa and measured the time of fall and observed that it does not depend on the weight of the material object. Eagleman dropped subject persons instead of stones!

First of all Eagleman constructed an instrument which he calls perceptive chronometer producing random sequence of digits. In the simplest situation only single digit appeared alternatively as its positive or negative. As the rate of digits exceeds certain critical rate -presumably rather near to 12.5 Hz under normal circumstances- it becomes impossible to distinguish between subsequent digits: one sees only single fuzzy digit. The critical duration for the digit defines a natural unit of subjective time. The idea is to calibrate the rate of the chronometer in such a way that the subject person is not able to distinguish between digits but that only a small reduction of the digit rate makes this possible. In this kind of situation it is enough to make the person scared and see whether he becomes able to distinguish between subsequent digits.

What Eagleman wanted to test was whether this time resolution increases when a person is really scared. If so, the subjective time measured using this critical unit would be longer in scaring situations. The method of really scaring was ingenious: drop the person from quite high a tower! During the free fall the person first found the critical time resolution of his visual perception which became the time unit used to measure the time of fall. The rate for Person reported his time resolution in two cases: when another person was falling and during own fall. The resolution increased during own fall: the falling time was estimated to be about 36 per cent longer for own falling down using the resolution as a unit.

What does this mean? It seems that the rate of the experienced time flow depends on the level of neural activity. In TGD framework the proper measure of subjective time is single quantum jump (recall that they form fractal hierarchy): this would be the tick of subjective clock. The larger the number of these ticks in a given interval of geometric time, the longer the experienced time duration is. More abstractly: the number of sub-CDs within CD representing mental images of self would provide a measure for the number of ticks during single CD.

Since metabolic energy is the necessary prerequisite for the build-up of sensory and cognitive representations (mental images), the prediction is that the rate with which metabolic energy is used by brain correlates directly with the rate of the experienced time flow. When the subject person is falling from a tower, the rate of brain metabolism is higher than normally so that the observations can be understood in terms of the theory. As a matter fact, the correlation of the subjective duration with neural activity is well-known in neuroscience and Eagleman gives a long list of examples.

2. *Odd ball effect*

In this experiment the subject person perceives a series of figures. The figures are identical apart from some odd-balls between the repeating ones. The duration of odd-ball is experienced to be longer than that of the repeating picture although it is the same. The explanation would be that brain wants to save energy. Less metabolic energy for repeating items and more metabolic energy

for odd-balls, which literally wake-up the partially sleeping brain. The rate of neural metabolism correlating with the intensity of conscious experience (and number of quantum jumps per unit of geometric time/density of sub-CD: s within CD) seems to correlated directly with the experienced slowing down of time.

To sum up, the findings discussed by Eagleman are not easy to understand in the standard conceptual framework of neuroscience. The basic assumptions of TGD inspired theory of consciousness make the explanation trivial. In particular, the hierarchy of quantum jumps containing quantum jumps (of selves having sub-selves with sub-selves interpreted as mental images of self) and having as an embedding space correlate the hierarchy of CDs within CDs, explains the correlation of neural metabolic energy consumption with the experienced rate for the flow of subjective time. The higher the density of sub-CDs within CD representing mental images, the higher the intensity of conscious experience, the higher the consumption of metabolic energy to build mental images, and the shorter the average time interval taken by given mental image and serving as a natural unit of subjective time and the longer the experienced duration of time interval.

5.7 Some comments related to quantum measurement theory according to TGD

In the following some comments on quantum measurement theory inspired by FB discussions. The TGD view about time is involved because measurement theory in TGD relies crucially on zero energy ontology (ZEO).

5.7.1 Does the analog of repeated second quantization take place at the level of WCW?

The world of classical worlds (WCW) is the basic structure of quantum TGD. It can be said to be the space of 3-surfaces consisting of pairs of (not necessarily connected 3-surfaces) at the boundaries of causal diamond (CD) and connected by a not necessarily connected 4-surface. 4-surface defines the interaction between the states associated with the 3-surfaces. The state associated with given 3-surface correspond to WCW spinor and one has modes of WCW spinor fields. WCW decomposes to sub-WCWs assignable to CDs and effectively the universe reduces to CD.

The key idea is that the WCW spinor fields are purely classical spinor fields. No second quantization is performed for them. Second quantization of induced spinor fields at space-time level is however carried out and gamma matrices of WCW anticommuting to its Kähler metric are linear combinations of fermionic oscillator operators.

The classicality of WCW spinor fields looks somewhat problematic.

1. The classicality of WCW spinor fields has implications for quantum measurement theory. State function reduction involves reduction of entanglement between systems at different points of space-time and therefore also many-particle states and second quantization are involved. However, second quantization does not take place at the level of WCW and it seems that entanglement between two 3-surfaces is not possible. Therefore measurements at WCW level should correspond to localizations not involving a reduction of entanglement. Measurements could not be interpreted as measurements of the universal observable defined by density matrix of subsystem. This looks problematic.
2. At the space-time level second quantization is a counterpart for the formation of many-particle states. Particles are pointlike and one of the outcomes is entanglement between point like particles. Since the point of WCW is essentially point-like particle extended to 3-surface, one would expect that second quantization in some sense takes place at the level of WCW although the theory is formally purely classical.
3. Also the hierarchy of infinite primes suggests an infinite hierarchy of second quantizations. Could it have counterpart at the level of WCW: can WCW spinor field be second quantized and classical simultaneously?

Could the counterpart for the hierarchy of infinite primes and second quantization be realized automatically at WCW level? One can indeed interpret the measurements at WCW as either localizations or as reductions of entanglement between states associated with different points of WCW. The point is that the disjoint union of 3-surfaces X^3 and Y^3 can be regarded either as a pair (X^3, Y^3) of 3-surfaces in $WCW \times WCW$ or as a 3-surface $Z^3 = X^3 \cup Y^3 \subset WCW$. The general identity behind this duality $WCW = WCW \times WCW = \dots = WCW^n = \dots$

One could think the situation in terms of $(X^3, Y^3) \in WCW \times WCW$ in which case one can speak of entanglement between WCW spinor modes associated with X^3 and Y^3 reduced by the measurement of density matrix. Second interpretation as a localization of wave function of $Z^3 = X^3 \cup Y^3 \in WCW$.

5.7.2 About the notion of observable

In ordinary quantum theory observables are hermitian operators and their eigenvalues representing the values of observables are real.

In TGD using $M^4 \times CP_2$ picture the gauge coupling strengths are complex and therefore also classical Noether charges are complex. This should be the case also for quantum observables. Total quantum numbers could be still real but single particle quantum numbers complex. I have proposed that this is true for conformal weights and talked about conformal confinement.

Also in ordinary twistor approach virtual particles are on mass shell and thus massless but complex. Same is expected in TGD for 8-momenta so that one obtains particles massive in 4-D sense but massless in 8-D sense: this is absolutely crucial for the generalization of twistor approach to 8-D context. Virtual momenta could be massless in 8-D sense but complex but *total* momenta would be real. This would apply to all quantal charges, which for Cartan algebra are identical with classical Noether charges.

I learned also a very interesting fact about normal operators for which operator and its hermitian conjugate commute. As the author mentions, this trivial fact has remained unknown even for professionals. One can assign to a normal operator real and imaginary parts, which are commuting as hermitian operators so that - according to the standard quantum measurement theory - they can be measured simultaneously.

For instance, complex values of various charge predicted by twistor lift of TGD would therefore in principle be allowed even without the assumption that the total charges are real (*total* charges as hermitian operators). Combining the two ideas one would have that single particle charges are complex and represented by normal operators and total charges are real and represented by hermitian operators.

5.7.3 What does amplification process in quantum measurement mean?

Quantum measurement involves an amplification process amplifying the outcome of state function reduction at single particle level to a macroscopic effect. This aspect of quantum measurement theory is poorly understood at fundamental level and is usually thought to be unessential concerning the calculation of the predictions of quantum theory.

The intuitive expectation is that the amplification is made possible by criticality - I would suggest quantum criticality - and involves the analog of a phase transition generated by seed. This is like the change for a direction of single spin in magnet at criticality inducing change of the magnetization direction.

Quantum criticality [K36, K37, K38, K39] involves long range fluctuations and correlations for which $\hbar_{eff}/\hbar = n$ serves as a mathematical description in terms of adelic physics in TGD framework. Long range correlations would make possible the classical macroscopic state characterizing the pointer. This large $\hbar_{eff}/\hbar = n$ aspect would naturally correspond to the presence of intelligent observer: \hbar_{eff} indeed closely relates to the description of not only sensory but also cognitive aspects of existence and has number theoretic interpretation as a measure for what might be called IQ of the system.

If this is the case, one cannot build proper quantum measurement theory in the framework of standard quantum mechanics, which is unable to say anything interesting about cognition and observer. A theory of consciousness is required for this and ZEO based quantum measurement theory is also a theory of consciousness.

5.7.4 Zero energy ontology and Afshar experiment

Afshar experiment [D36] challenges Copenhagen and many-universe interpretations (see <http://tinyurl.com/ycsttpb9>) and it is interesting to look how it can be understood in ZEO.

Consider first the experimental arrangement of Afshar.

1. A modification of double slit experiment is in question. One replaces the screen with a lense, which reflects from slit 1 to detector 1' and from slit 2 to detector 2'. Lense thus selects the photon path that is the slit through which the photon came.

The detected pattern of clicks at detectors consists of two peaks: this means particle behavior. One can say that at single photon level either detector/path/slit is selected.

2. One adds a grid of obstacles to the nodes (zeros) of the interference pattern at imagined screen behind the lense. The photons entering the points of grid are absorbed. Since grid is at nodes of the interference pattern this does not affect the detected pattern, when both slits are open but affects the pattern when either slit is closed (grids points are not nodes anymore). This in turn means wave like behavior. This conflicts with principle of complementarity stating that either of these behaviors is realized but not both.

Consider the analysis of the situation in the usual positive energy ontology and assuming that state function reduction occurs at the detectors.

1. Photon wave function Ψ in the region between slits and lense is superposition of two parts: $\Psi = \Psi_1 + \Psi_2$ with Ψ_i assignable to slit $i = 1, 2$. The lense guides Ψ_1 to detector 1 and Ψ_2 to detector 2. State function reduction occurs and Ψ is projected to Ψ_1 or Ψ_2 . Either detector 1 or 2 fires and photon path is selected.

It however seems that state function reduction - choice of the path/slit - can occur only in the region in front of the grid. In the region between slits and grid one should still have $\Psi_1 + \Psi_2$ since for Ψ_i the grid would have effect to the outcome. This effect is however absent. This does not fit with Copenhagen interpretation demanding that the path of photon is selected also behind the grid. This is the problem.

2. What about the interpretation in ZEO? After state function reduction - detection at detector 1 say - the time evolution between opposite boundaries of CD is related with a time reversed one. To explain the observations of Afshar (no deterioration of the pattern at detector caused by grid), one must have time evolution in which the photons coming from the detectors in reversed time direction have wave functions which vanish at the points of grid. This determines the "initial" values for the reversed time evolution: they are most naturally at grid so that grid corresponds naturally to a surface at boundary of CD in question. This is of course not the only choice since one can use the determinism of classical field equations to choose the intersection with CD differently. If time reversal symmetry holds true, the final state in geometric past corresponds to a signal coming from slit 1 (in the case considered as example). There would be no problem! Afshar experiment would be the first laboratory experiment selecting between Copenhagen interpretation and ZEO based quantum measurement theory.

5.8 Maxwell's demon from TGD viewpoint

In Facebook I received a link to an interesting popular Science News article titled "*A New Information Engine is Pushing the Boundaries of Thermodynamics*" (see <http://tinyurl.com/y74bfrpu>). The article told about the progress in generalizing the conventional second law of thermodynamics to take information as an additional parameter.

Carnot engine is the standard practical application. One has two systems A and B, both in thermal equilibrium but with different temperatures T_A and $T_B \geq T_A$. By second law one has heat flow Q from A to B the two systems, and Carnot's engine transforms some of this heat to work. Carnot's law gives an upper bound for the efficiency of the engine as $\eta \equiv W/Q \leq (T_2 - T_1)/T_2$. The possibility to transform information to work forces to generalize Carnot's law.

Since information is basically conscious information, this generalization is highly interesting from the point of view of quantum theories of consciousness and quantum biology. Certainly the generalization is highly non-trivial. Especially so in standard physics framework, where only entropy is defined at fundamental level and is regarded as ensemble entropy and basically has very little to do with conscious information. Therefore the argumentation is kind of art work.

5.8.1 Maxwell's demon in its original form

Maxwell's demon (see <http://tinyurl.com/q829my5>) is a thought experiment in which one considers a system consisting of two volumes A and B of gas in thermal equilibrium at same temperature. At the boundary between A and B having a small hole sits a demon checking whether a molecule coming from A has velocity above some threshold: if so it allows the molecule to go to B. Demon monitors also the molecules coming from B and if the velocity is below the threshold it allows the molecule to continue to A. As a consequence, temperature and pressure differences develop between A and B. Pressure difference can do work very much voltage between the cathode and anode of battery. One can indeed add a tube analogous to wire between ends of the entire system and pressure difference causes a flow of mass doing thus work: one has pump.

The result is in conflict with the second law and one can ask what goes wrong. From the Wikipedia article one learns that a lot of arguments have been represented con and pro Maxwell's demon. Biologist might answer immediately. Demon must measure the states of molecules and this requires cognition and memory, which in turn require metabolic energy. When one takes this into account this, paradox should disappear and second law should remain true in a generalized form in which one takes into account the needed metabolic energy.

5.8.2 Experimental realization of Maxwell's demon

The popular article describes an experiment actualizing Maxwell's demon carried out by Govind Paneru, Dong Yun Lee, Tsvi Tlusty, and Hyuk Kyu Pak (see <http://tinyurl.com/y9sn9j7o>). Below is the abstract of the article *Lossless Brownian Information Engine* published in Phys Rev Letters.

We report on a lossless information engine that converts nearly all available information from an error-free feedback protocol into mechanical work. Combining high-precision detection at a resolution of 1 nm with ultrafast feedback control, the engine is tuned to extract the maximum work from information on the position of a Brownian particle. We show that the work produced by the engine achieves a bound set by a generalized second law of thermodynamics, demonstrating for the first time the sharpness of this bound. We validate a generalized Jarzynski equality for error-free feedback-controlled information engines.

Unfortunately, the article is behind paywall and I failed to find it in arXiv. The popular article uses notions like "particle trapped by light at room temperature" and photodiode as "light trap" without really defining what these expressions mean. For instance, it is said that the light trap would follow particles moving in definite direction (from A to B in Maxwell's thought experiment). I must admit that I am not at all sure what the precise meaning of this statement is.

5.8.3 TGD view about the situation

TGD inspired theory of consciousness can be regarded as a quantum measurement theory based on zero energy ontology (ZEO) and it is interesting to try to analyze the experiment in this conceptual framework.

TGD view about the experiment

The natural quantum interpretation is that the photodiode following the photon is performing repeated quantum measurements, which in standard quantum theory do not affect the state of the particle after the first measurement. From the viewpoint of TGD inspired consciousness, which can be regarded as a generalization of quantum measurement theory forced by zero energy ontology (ZEO), the situation could be as follows.

1. Photo-diode following the particle by would be like conscious entity directing attention its to the particle and keeping it in focus. In TGD Universe directed attention has as classical space-time correlates flux tubes connecting attendee and target of attention: in ER-EPR correspondence the flux tubes are replaced with wormholes, which suit better to GRT based framework. Flux tubes make also possible entanglement between attendee and target. The two systems become single system during the period of attention and one could say that the attention separates the particle from the rest.

2. Directed attention costs metabolic energy. Same would be true also now - photo-diode indeed requires energy feed. Directed attention creates mental image the conscious entity associated with the mental images can be regarded as a generalized Zeno effect or as a sequence of weak measurements.

Tracking would thus mean that particle's momentum is measured repeatedly so that the particle is forced to continue with the same momentum. Gradually this would affect the thermal distribution and generate temperature and pressure gradients. Directed attention could be also seen as a mechanism of volition in quantum biology.

3. This looks nice but one can ask what about the collisions of the particle with other molecules of gas: don't they interfere with the Zeno effect? If the period between repeated measurements is shorter than the average time between the collisions of particles, this is not a problem. But is there any effect in this case? The directed attention or a sequence of quantum measurements could separate the particle from the environment by de-entangling it from the environment. Could it be that collisions would not occur during this period so that attendee and target would form a subsystem de-entangled from rest of the world?

ZEO variant of Maxwell's demon

Zero energy ontology (ZEO) [L58] forces to consider different arrangement producing energy somewhat like in perpetual mobile but not breaking the conservation of energy in any obvious manner. The idea pops into my mind occasionally and I reject it every time and will do so again.

1. Zero energy states (ZESs) are like physical events: pairs of positive and negative energy state with energy E and $-E$: this codes for energy conservation.
2. One can have quantum superposition of ZESs with different values of energy E and with average value $\langle E \rangle$ of energy. In state function reduction $\langle E \rangle$ can change and in principle this does not break conservation of energy since one has still superposition of pairs with energies E and $-E$.
3. For instance, the probabilities for states with energy E could be given by thermal distribution parameterized by temperature parameter T : one would have "square root" of thermodynamic distribution for energies. "Square root" of thermodynamics is indeed forced by ZEO. One would have essentially entanglement in time direction. Single particle states would realize square root of thermodynamical ensemble, which would not be a fictive notion anymore.

The coefficients for the state pairs would have also phases and these phases would bring in something new and very probably very important in living matter. System characterized by temperature T would not be so uninteresting as we think, there could be hidden phase information.

If T increases in reduction then $\langle E \rangle$ increases in state function reduction. Reduction could also measure the value of E . Could the system increase its $\langle E \rangle$ in state function reductions? My proposal for an answer is "No".

In ordinary thermodynamics energy should be fed from environment to increase $\langle E \rangle$: how environment would enter into the game now?

1. State function reduction always reduces the entanglement of system S with environment, call it S_{env} . Could the increase of $\langle E \rangle$ be compensated by compensating change of $-\langle E \rangle$ in S_{env} . Indeed, the conservation of energy for single state is expected have statistical counterpart: energy would come from environment as a kind of metabolic energy. Therefore also the "square root" of thermodynamics would prevent perpetual mobile.

2. This would be the case if the reduction measures the energy of the entire system $S_{tot} = S + S_{env}$ - so that S_{tot} is always in energy eigenstate with eigenvalue E_{tot} and E_{tot} does not change in reductions and in unitary evolutions between them. Can one pose this condition?

Time reversal and apparent breaking of second law in zero energy ontology (ZEO)

ZEO based theory of consciousness [L58] forces to consider also a genuine breaking of the second law.

1. In ZEO self as a conscious entity corresponds to a generalized Zeno effect or equivalently a sequence of analogs of weak measurements as “small” state function reductions. The state at passive boundary of CD is unaffected as also the members of state pairs at it.

Second boundary of CD (active boundary) shifts farther away from the passive one and the members of state pairs at it change giving rise to the conscious experience of self. Clock time identified as temporal distance between the tips of CD increases. This gives rise to the correspondence between clock time and subjective time identified as sequence of weak reductions.

2. Also “large” state function reductions are possible and also unavoidable. The roles of active and passive boundary are changed and time reversal occurs for the clock time. One can say that self dies and re-incarnates as a time-reversed self.

At the next re-incarnation self with the original arrow of clock time would be reborn and continue life from time value shifted towards future from the moment of death: its identity as a physical could be however very different. One can of course wonder whether sleep could mean a life in opposite direction of clock time and wake-up a reincarnation in the usual sense.

The time-reversed self need not have conscious memories about its former life cycle: only the collections of un-entangled subsystems at passive boundary carry information about this period. A continuation of conscious experience could however take place in different sense: the contents of consciousness associated with the magnetic body of self could survive the death as near-death-experiences indeed suggest.

3. The time reversed system obeys second law but with opposite time direction as normally. Already Italian physicist Fantappie proposed that this occurs routinely in living matter and christened the entropy for time reversed systems syntropy [J92]. Processes like spontaneous assembly of complex molecules from their building bricks could be controlled by time reversed selves.

In TGD inspired biology motor actions could be seen as generation of signal propagating backwards in time and defining sub-system with reversed arrow of time and inducing the activity preceding motor activity before the conscious decision leading to it is made: this with respect to geometric time. There are many effects supporting the occurrence of these time reversals.

4. How the possibility of time reversals relates to the second law? One might argue that second law emerges from the non-determinism of state function reduction alone. Second law would transform to its temporal mirror image when one looks the system from outside with unchanged arrow of clock time.

But does the second law continue to hold in statistical sense as one takes average over several incarnations? One might think that this is the case since generalized Zeno effect generalizes ordinary Zeno effect and at the limit of positive energy ontology one would effectively have a sequence of ordinary state function reductions leading leading to second law.

Negentropy Maximation Principle (NMP)

TGD also predicts what I call Negentropy Maximization Principle (NMP) [K73] [L58].

1. Entanglement coefficients belong to extension of rationals allowing interpretation as both real and p-adic numbers in the extension of p-adics induced by the extension of rationals defining the adele.

One can assign ordinary entanglement entropy to the real sector of adele and entanglement negentropy with the p-adic sectors of adelic physics: for latter the analog of ordinary Shannon entropy is negative and thus the interpretation as conscious information is possible. The information is assigned with the pairing defined by entanglement whereas entropy is associated with the loss of precise knowledge about the state of particle in entangled state.

2. One can also consider the difference of sum of p-adic entanglement negentropies and real entanglement entropy as the negentropy. This quantity can be positive for algebraic extensions of rationals and its maximal value increases with the complexity of the extension and with p-adic prime.

Also the information defined in this manner would increase during evolution assignable to the gradual increase of dimension of algebraic extension of rationals, which can take place in "large" state function reductions (re-incarnations of self): if the eigenvalues of density matrix are algebraic numbers in an extension of the extension of rationals, the "large" state function must take place.

3. NMP would hold true in statistical sense - and mathematically very much analogous to second law - and would relate to evolution. In particular, one can understand why the emergence of intelligent systems is - rather paradoxically - accompanied by the generation of entropy. To have large entanglement negentropy in p-adic sectors one must have large entanglement entropy in real sector since same entanglement defines both.

Dark matter as phases of matter labelled by the hierarchy of Planck constants

The hierarchy of Planck constants $h_{eff}/h = n$ [K36, K37, K38, K39, K88] is a further key notion in TGD inspired quantum biology.

1. The hierarchy of Planck constants $h_{eff}/h = n$ implied by adelic physics as physics of both sensory experience (real numbers) and cognition (p-adic number fields) is basic prediction of TGD [L56]. Planck constant characterizes the dimension of the algebraic extension of rationals characterizing the cognitive representations, and is bound to increase since the number of extensions with dimension larger than given dimension is infinite whereas those with smaller dimension is finite.
2. The ability to generate negentropy increases during evolution. System need not however generate negentropy and can even reduce it. In statistical sense negentropic resources however increase: things get better in the long run. In biology metabolic energy feed brings to system molecules having valence bonds with $h_{eff}/h = n$ larger than that for atoms [L51], and this increases the ability of the system to generate negentropy and in statistical sense this leads to the increase of negentropy.

The most recent ZEO based view about demonic activities in TGD Universe

Maxwell's demon is at the boundary of the region which can be seen as physics disregarding totally the observer. Maxwell's demon allows only particles with velocity above threshold to travel from A to B. This leads to generation of pressure gradient in conflict with the second law.

The basic objection against Maxwell's demon is that the demon is an intelligent living being which thinks and although there is no mainstream physical theory about cognition, the empirical fact is that this requires metabolic energy feed. This must be taken in account also and means that the development of the gradient requires metabolic energy.

In zero energy ontology (ZEO) one must reconsider the situation since time reversal occurs in ordinary state function reductions (BSFRs) [L89]. This means time reversed dissipation and forces a generalization of the second law [L87]. For the observer with the standard arrow of time, this shows itself as a generation of various gradients, demonic activity.

Living matter is full of examples of self-organization in which such this seems to happen and the explanation is in terms of non-equilibrium thermodynamics and thermodynamical fluctuations basically. Essential is that energy flows are involved as in the example of Maxwell demon and metabolic energy feed explains this partially. But eventually the energy flows are gradients and

eventually disappear and heat death of the Universe occurs. The emergence of life therefore seems very implausible: England [?] would be thus incorrect [L28].

Usually the energy flow to the system is taken as passive - arranged from outside. In ZEO the opposite arrow of time makes it active. System extracts energy from the environment, "eats" rather than waiting for the food to flow into its mouth spontaneously and to creep to the stomach without help. This leads to what I call remote metabolism or credit card mechanism as a way to extract radiative energy from the environment or from systems analogous to population inverted lasers able to provide it.

Living matter is also full of examples about self-organized criticality (SOC) very difficult to understand in standard thermodynamics. System manages to stay near a critical state which is by definition unstable. This is nothing but homeostasis [L170]. What in standard biology looks like extremely tightly planned programs involving endlessly various biochemical pathways is unplanned spontaneous dissipation with a reversed arrow of time: this simplifies enormously the biological modelling. In time reversed direction critical state is an attractor rather than repeller and time reversal would be the basic mechanism of homeostasis.

There are specific molecules - stress proteins (SPs) specialized to act as coolers, heaters, and heat engines using the thermal energy at their magnetic body (MB), whose temperature has maximum - presumably near physiological temperature - by the fact the number of degrees of freedom is infinite [L170]. SPs a near this maximal temperature known as Hagedorn temperature and have very large heat capacity. Stress molecules provide in the case of cold shock energy to DNA and basic proteins to heat them so that they remain functional. In the case of heat shock they reduce the temperature of the environment by sucking thermal energy by time reversal for their magnetic body serving as an energy reservoir. They can act also as heat engines driving molecular motors.

5.9 Why the outcome of an event would be more predictable if it is known to occur?

I learned from Reza Rastmanesh about highly interesting findings of Armor and Sackett, and this section is essentially the article [L174] written together with him about the topic.

Past research in experimental psychology has brought evidence showing that certain changes in internal neurocognitive environments of human subjects can influence their predictions of near future events. In the series of experiments published in a recognized psychological Journal of Personality and Social Psychology, Armor and Sackett [J22] examined how the nature of future events influence the participants' predictions about their future performance in different tasks.

In Study 1, half of participants were informed that they will complete a scavenger hunt task, i.e. finding particular objects at the university campus during 30 minutes, whereas the second half of participants were not informed. Thus, the expectations of participants were manipulated in terms of real versus hypothetical future events and this manipulation also causes different changes in internal neurocognitive environments in each half of participants. The participants were asked "How well will you do on the scavenger hunt?" or "How well would you do, if you were asked to complete the scavenger hunt?". After that, all the participants completed the scavenger hunt task and their predictions were compared with their real performance in this task. Strikingly, participants who did expect to complete the task predicted their own performance quite accurately. In contrast, participants who believed that the task is only a hypothetical future event showed much higher prediction-performance discrepancy, i.e. they were not able to predict their future performance accurately.

These findings were replicated also in Study 2, where another kind of task was used (a completion of test used for Graduate Record Examination). One may ask how it is possible that participants that were informed about their future life event predicted their real performance in the task better than non-informed participants. The authors of this study were quite surprised by obtaining these results and labeled them as "seemingly anomalous findings". If this finding is real it provides a difficult challenge for model builders.

In the context of Minkowski spacetime, several possible explanations can be theoretically conceptualized:

1. In classical GRT, the causal structure is the structure of light cones of the space-time metrics. As the matter-energy degrees of freedom determine the metric through Einstein's equations, the causal structure of a region of space-time is dynamical: it depends on the state of the matter energy in its past light cone. If one identifies the causality of human actions experienced as acts of free will with the deterministic causality of field equations, the ability to predict the near future is theoretically possible. This applies also to person's own behavior if it does not involve free will: if this is the case, the two causalities cannot be identified.
2. Also a general quantal explanation may be considered. Quantum measurement provides information. In the context of the above-outlined experiments, the participants who were told about the purpose of the experiment gained information. Could this action have involved state function reduction of some kind improving the ability to predict their own future? Also this option would assume that HOs are passive inspectors of their own fate and does not conform to the direct experience of having (partially) free will.
3. One can consider also an explanation in terms of precognition based on future-to-past communications requiring change of the arrow of time and therefore also violation of standard thermodynamics. Precognition is classified as belonging to the field of parapsychology by materialists accepting only a single arrow of time. Also this explanation fails if one accepts free will: precognizing of own unpredictable acts of free will is impossible.

In the sequel the problems of various physicalistic explanations are discussed in more detail and the TGD based model relying on zero energy ontology (ZEO) [L89] replacing the standard ontology of quantum theory in TGD framework and solving the basic paradox of quantum measurement theory. The basic prediction is that the arrow of time changes in "big" (ordinary) states function reductions (BSFRs) but is preserved in "small" SSFRs as analogs of "weak" measurements. This forces to distinguish between geometric and subjective time.

This leads to an understanding of the findings of Libet [J23] about active aspects of consciousness challenging the reality free will: in BSFR the arrow of causality changes and the outcome of BSFR causes the neural activity rather than vice versa. Also the findings of Armor and Sackett seem to give direct support for the physicalistic picture: the members of group A would be passive inspectors of their own future actions and therefore would have not free will. Precognition, which is not accepted in the physicalistic framework, is however required, which suggests that BSFRs transforming precognition to memory recall might be involved.

In the sequel the findings of Armor and Sackett are taken at face value and an explanation based on TGD inspired theory of consciousness relying on zero energy ontology (ZEO) allowing to get rid of the basic paradox of quantum measurement theory is proposed. There are 2 new elements essential for the explanation.

1. There is a hierarchy of magnetic bodies carrying dark matter as $h_{eff} = nh_0$ phases of ordinary matter and defining a self-hierarchy.
2. The time reversal in BSFRs makes memory recall in reversed time direction possible: these memories need not be personal and it is possible to get information about the memories of MB at a higher level of hierarchy with a reversed arrow of time after BSFR.

In the scavenger hunt BSFR at higher level would be assignable to the experiment which had already occurred with respect to subjective time at a higher level of the hierarchy in the geometric future of participants. This BSFR would be followed by a cascade of BSFRs proceeding to shorter scales in subjective future but located in the geometric past.

The subject persons who were told that they will participate a scavenger hunt would have received non-personal memories about those abstract aspects of the scavenger hunt at higher level of hierarchy, which they could not affect by BSFRs: the number of objects found by the participant would have been this kind of aspect and already determined by a BSFR at a higher level of hierarchy. Ordinary motor action would be very similar process involving communications to lower levels of self hierarchy in the geometric past.

This explanation is akin to the earlier TGD based explanation [L26] [K128] for psychedelic experiences in which subject persons experience meeting of representatives of advanced civilizations of outer space. That these encounters could be actual telepathic contacts was proposed in

a book about psychedelic induced experiences titled as “Inner paths to outer space” (<http://tinyurl.com/gnb4bp9>) written by Rick Strassman, Slawek Wojtowicz, Luis Eduardo Luna and Ede Frecska [J69]. In ZEO the arrow of time is not fixed so that instantaneous communications over arbitrarily long distances become possible by what might be called time reflection involving BSFR.

The explanation relies on sending a signal, which is reflected back as a time reversed signal (involving BSFR): this allows to circumvent the barrier caused by finite speed of light. In principle this would make signalling with arbitrarily distant civilizations possible.

5.9.1 Why the standard physics based explanation for the findings of Armor and Sackett looks implausible?

What seems clear to me is that it is very difficult to understand the findings of Armor and Sackett [J22] - if real - in the standard physics framework.

1. Standard physics excludes precognition: the thermo-dynamical arrow of time is fixed and also the quantization procedure of quantum field theory fixes the arrow of time. Creation operators create states and annihilation operators destroy them. The change of arrow of time would change the roles of these operators. Classically this corresponds to the fact that signals propagate in preferred direction only. It is difficult to see how quantum effects according to standard QM could help. State function reductions happen in standard physics only in very short scales and have no effect in macroscales. They do not make possible effective precognition.
2. The idea that the persons in group A got bored after they had found the number of objects that they had estimated to find does not work since the same should have happened in group B.
3. The experimenter effect [K71] is encountered in parapsychology experiments and also in experiments involving living subjects (testing of drugs). There are extremely successful parapsychology experimenters and often their findings cannot be replicated. Could the experimenters somehow affect the subject persons so that the outcome of the experiment is what the experimenter would regard as desired? Physicalists deny the possibility of this kind of effect so that fraud or bad experimentation remains the only explanation. The reality of Placebo effect cannot be denied and suggests that the state of mind of the patient affects the healing in conflict with the physicalistic expectations. These effects are discussed from the TGD point of view in an article [K71] prepared in the project organized by Lian Sidoroff. Experimenter effect leads to ask whether the strong belief of experimenter on the expected result could induce the result also in the experiment of Armor and Sackett. This hypothesis could be tested by replicating the experiment sufficiently many times by other experimenters.
4. The causal reference frame model of Guerin and Bruckner [J22] involves a rather speculative proposal that classical GRT could allow anomalies in which the order of events is different for different observers modelled in terms of lightcones. One can ask whether it could differ in the recent experiments between participants a in group A and participants b in group B. For persons in group A it would have been changed and they could “remember” their performance whereas the participants in B only estimated it since they did not know that effective memory recall is possible! The information would have entered as classical signals in reversed time direction to the participants in group A. Somehow the information about the participation to the actual experiment would have made possible this effective change of arrow of time.

Classical Relativity predicts that gravitation is extremely weak interaction so that the explanation does not look plausible to me. There are however some black-hole like solutions of Einstein’s equations known as Kerr-Newman metrics [B17] describing rotating objects having opposite arrows of time in near-field and far-field regions but these solutions do not seem relevant in the recent case.

It is difficult to see how standard quantum physics could help. One must however notice that there is no generally accepted quantum theory of gravitation.

5.9.2 A model for the findings of Armor and Sackett based on the notions of magnetic body (MB) and zero energy ontology (ZEO)

TGD based explanation of the findings relies on the notions of magnetic body (MB) and zero energy ontology (ZEO).

The notion of magnetic body (MB)

The notion of classical field differs from that of classical field theories. Gauge potentials - in particular electromagnetic gauge potential - are induced from the spinor connection of embedding space $M^4 \times CP_2$ as defining static and non-dynamical gauge potentials. Same applies to gravitational field as deviation from flat metric of Minkowski space. The dynamics of space-time surface makes the induced gauge potentials and metric dynamical. Locally the dynamics is however extremely simple since only 4 field like variables are involved. Even approximate superposition of fields is lost and possible only for massless modes propagating in the same direction and is replaced with superposition of effects.

This extreme local simplicity is compensated by the extremely complex topology of the many-sheeted space-time distinguishing TGD from standard model plus General Relativity. Many-sheeted space-time prevailing in long length scales means that there is very large number of space-time sheets parallel in the sense that they intersecting 4-D M^4 projections. This is crucial for all applications. Any system the induced gauge fields at space-time sheets characterizing the system and since these sheets are separate for separate system, these induced fields do not interfere. One can say that the system has field body, in particular magnetic body (MB). In gauge theories this is not the case.

How does this picture relate to ordinary field theoretic description. Particle like entity as a small 3-surface touches all space-time sheets with 4-D M^4 projection and therefore experiences the sum of induced gauge fields associated with the space-time sheets. Effects superpose and this superposition corresponds basically to a set theoretic union of space-time surface with intersection M^4 projections. In ordinary field theory this is used as justification for the assumption that fields superpose. Field theory limit of TGD is defined by replacing the many-sheeted space-time with single regions of M^4 with gauge fields and gravitational fields defined as superpositions of the induced fields.

Also brain has MB. Quite generally MB is assumed to contain dark matter identified as ordinary matter characterized by extension of rationals with dimension $h = h_{eff}/h_0 = n$ measuring algebraic complexity and having interpretation as a kind of universal IQ. Also the scales of quantum coherence increase with h_{eff} . The layers of MB characterized by the value of n form naturally a slaving hierarchy in which ordinary matter with smallest Planck constant is at the bottom and controlled by higher levels. The energies of systems increase with h_{eff} and since h_{eff} tends to be spontaneously reduced, energy feed is needed to preserve the distribution of h_{eff} : the interpretation is as metabolic energy feed.

In the TGD framework the onion-like hierarchical structures of MB of brain would correspond to brain regions. The structure of MB with levels labelled by extensions of rationals characterized partially by $n = h_{eff}/h_0$ measuring the scale of quantum coherence, would also reflect the geometric and topological structure of the brain. There is evidence that functionally similar neurons can be modelled using statistically determined hyperbolic geometry [J50]. Functionally similar neurons not necessarily near to each other physically would be near to each other in the effective hyperbolic geometry.

In TGD framework MB could realize this hyperbolic geometry quite concretely as an abstract representation of the hierarchical functional structure of brain [L93]: functionally similar neurons and also higher level structures would be connected to nearby points at MB by flux tubes. Classification experienced as putting similar things to the same box is one of the basic cognitive functions and hierarchy of MBs could realize classification geometrically: functionally similar neurons would be connected by flux tubes to points near each other at MB - they would belong to the same box.

There is an astonishing finding supporting the notion of MB. The neurons of the brain of salamander were shuffled like a pack of cards. The salamander however recovered and preserved its memories (identified as learned behaviors) [J109]. In [K92, K94] this finding was considered

as a support for the view about the brain as an analog of hologram (for the idea about TGD Universe as a conscious hologram see [K20]). It is however clear that a single neuron cannot represent the information content of the entire brain. However, if memories are represented by the images of neurons at the level of MB, the shuffling of neurons has no effect on memories as indeed found. Neurons would represent the analog of RAM in computer science.

What does ZEO mean?

The TGD based explanation would be based on ZEO allowing to solve the basic paradox of quantum measurement theory. First a brief summary of ZEO [L89].

1. In ZEO quantum states are not 3-dimensional but superpositions of 4-dimensional deterministic time evolutions connecting ordinary initial 3-dimensional states. By holography they are equivalent to pairs of ordinary 3-D states identified as initial and final states of time evolution.

Quantum jumps replace this state with a new one: a superposition of deterministic time evolutions is replaced with a new superposition. Classical determinism of individual time evolution is not violated and this solves the basic paradox of quantum measurement theory. There are two kinds of quantum jumps: ordinary ("big") state function reductions (BSFRs) changing the arrow of time and "small" state function reductions (SSFRs) (weak measurements) preserving it and giving rise to the analog of Zeno effect [L89].

2. To avoid confusion it is good to emphasize some aspects of ZEO.
 - (a) ZEO does not mean that physical states in the usual 3-D sense as snapshots of time evolution would have zero energy state pairs defining zero energy states as initial and final states have same conserved quantities such as energy. Conservation implies that one can adopt the conventions that the values of conserved quantities are opposite for these states so that their sum vanishes: one can think that incoming and outgoing particles come from geometric past and future is the picture used in quantum field theories.
 - (b) ZEO implies *two* times: subjective time as sequence of quantum jumps and geometric time as space-time coordinate. These times are identifiable but are strongly correlated.
3. In BSFRs the arrow of time is changed and the time evolution in the final state occurs backwards with respect to the time of the external observer. BSFRs can occur in all scales since TGD predicts a hierarchy of effective Planck constants with arbitrarily large values. There is empirical support for BSFRs.
 - (a) The findings of Minev *et al* [L82] in atomic scale can be explained by the same mechanism [L82]. In BSFR a final zero energy state as a superposition of classical deterministic time evolutions emerges and for an observer with a standard arrow of time looks like a superposition of deterministic smooth time evolutions leading to the final state. Interestingly, once this evolution has started, it cannot be stopped unless one changes the stimulus signal inducing the evolution in which case the process does not lead to anywhere: the interpretation would be that BSFR back to the initial state occurs!
 - (b) Libets' experiments about active aspects of consciousness [J23] can be understood. Subject person raises his finger and neural activity starts before the conscious decision to do so. In the physicalistic framework it is thought to lead to raising of the finger. The problem with the explanation [J18] is that the activity beginning .5 seconds earlier seems to be dissipation with a reversed arrow of time: from chaotic and disordered to ordered at around .15 seconds. ZEO explanation is that macroscopic quantum jump occurred and generated a signal proceeding backwards in time and generated neural activity and dissipated to randomness.

- (c) Earthquakes involve a strange anomaly: they are preceded by ELF radiation. One would expect that they generate ELF radiation. The identification as BSFR would explain the anomaly [L84]. In biology the reversal of the arrow of time would occur routinely and be a central element of biological self-organization, in particular self-organized quantum criticality (see [L87, L170]).

Some implications of ZEO

ZEO has profound implications for understanding self-organization [L87] and self-organized quantum criticality [L170] in terms of dissipation with non-standard arrow of time looking like a generation of structures. ZEO could also allow understanding of what planned actions - like realizing the experiment under consideration - could be.

1. Second law in the standard sense does not favor - perhaps even not allow - realization of planned actions. ZEO forces a generalization of thermodynamics: dissipation with a non-standard arrow of time for a subsystem would look like self-organization and planned action and its realization.

Could most if not all planned action be like this - induced by BSFR in the geometric future and only apparently planned? There would be however the experience of planning and realizing induced by the signals from geometric future by a higher level in the hierarchy of conscious entities predicted by TGD! In long time scales we would be realizing our fates or wishes of higher level conscious entities rather than agents with completely free will.

2. The notion of magnetic body (MB) serving as a boss of ordinary matter would be central. MB carries dark matter as $h_{eff} = nh_0$ phases of ordinary matter with n serving as a measure for algebraic complexity of extension of rationals as its dimension and defining a kind of universal IQ. There is a hierarchy of these phases and MBs labelled by extension of rationals and the value of n .

MBs would form a hierarchy of bosses - a realization for master slave hierarchy. Ordinary matter would be at the bottom and its coherent behavior would be induced from quantum coherence at higher levels. BSFR for higher level MB would give rise to what looks like planned actions and experienced as planned action at the lower levels of hierarchy. One could speak of planned actions inducing a cascade of planned actions in shorter time scales and eventually proceeding to atomic level.

3. This interpretation is actually not new. I proposed in [L167, L168] that motor actions could correspond to BSFRs and sensory percepts to their time reversals. It took still some time to realize that sensory perceptions naturally correspond to SSFRs ("weak" measurements), and that both BSFRs and SSFRs can occur with both arrows of time. Motor action would be a cascade of BSFRs with each BSFR inducing sensory perceptions as SSFRs at lower level inducing in turn motor actions as BSFRs in shorter time and length scales. The above model is a generalization of this picture.

The model

Could one apply ZEO also to the experiment under consideration?

1. Could one think that the experiment involving BSFR had in some sense already occurred (with respect to subjective time) when the experimenters got the idea to perform the experiment as a control signal from the geometric future? Experimenters and participants would have been like neurons in the brain of participants of Libet's experiment demonstrating that neural activity precedes experience about act of free will [J23]. They did what the already occurred experiment forced them to do. They of course had a lot of free will but not at this level of hierarchy of conscious entities but in shorter time scales and this made possible the needed preparations.
2. Experimenter informed the members of group A about the arrangement of the experiment. Therefore the members of group A concentrated on a process which was actually an attempt

to remember in a reversed time direction and they were successful. The participants in group B did not know that the experiment would be arranged and made only guesses.

3. The objection is that in applications to atomic systems, Libet's experiments and earthquakes, one speaks of what an outsider with the standard arrow of time observed. Now one however talks about the participants of experiments and BSFR would now affect them. Does this really make sense?

Here the notion of MB could come in rescue. BSFR would occur at the level of a collective MB of the system involving participants and experimenters and induce the outcome of BSFR and would change the arrow of time only at this level of MB. The participants at lower levels of hierarchy would receive information from the collective MB as time reversed control and communication signals. The signals would be received if the participant tunes herself to the correct wavelength - that is performs a memory recall, which would become possible after learning that the experiment will be actually performed.

5.9.3 How could the higher levels of MB use the brain to realize their free will?

The proposed model assumes that the experienced long terms goals (in the recent case the goal of experimenter to perform the experiment) correspond to SFRs that have already occurred at some higher layer of MB controlling the brain.

Neuroscience supports the view that frontal lobes are responsible for long term planning and decision making. They are involved also with the self model. This suggests that the highest layers of MB control frontal lobes. There would be a hierarchy of layers of MB having frontal lobes at the bottom.

Model for the coupling of MB with frontal lobes in terms of cognitive entanglement

A natural assumption is that the control of biological body by MB involves entanglement. Since frontal lobes are associated with high level cognition, this entanglement could be cognitive entanglement discussed in [L98]. Cognitive entanglement is a hierarchical entanglement between wave functions in hierarchy of sub-groups in the factorization of Galois group to a product $G_1 G_2 \dots G_n$ of sub-groups reflecting directly the representation of extension as extension of extensions of ... of rationals.

What is special is that entanglement is directed like attention and hierarchical just like for the slaving hierarchy. The entanglement between states in group algebras of G_1 and $G_2 \dots G_n$ is directed from boss G_1 to slave $G_2 \dots G_n$. Cognitive SFRs are cascades proceeding downwards and reducing entanglement. Negentropy Maximization Principle can however prevent the cognitive measurement cascade from proceeding down to G_n [L109] if it does not give rise to negentropy gain.

Long term goals could involve this kind of cognitive entanglement assignable to directed attention and motor actions as BSFRs at this layer of MB would produce what is experienced by the levels of the hierarchy with the standard arrow of time as a behavior with long term goals. This would produce what could be regarded as analog of precognition [L167] and identifiable as sensory perception of signals propagating to non-standard direction of time. Precognitive dreams would be an example of this.

What happens when frontal lobes are damaged?

This vision conforms with what happens when frontal lobes are damaged. Although intellectual abilities are not lost, long term planning is not possible and the patient loses the ability to initiate actions. Damage can also lead to idiot savant phenomenon [J40]. Although the person seems to lack conceptual thinking completely, he/she can possess miraculous looking mathematical skills [L41] [K104] or artistic gifts [L32] [L32]. In some poorly understood sense idiot savants can be extremely intelligent.

Is the character of the cognitive entanglement changed or replaced with something totally different in these situations? TGD predicts two kinds of information related to two different

representations of genetic code which relate to each other like function – represented by its local values – to its Fourier transform as a non-local and holistic representation [L96, L108]. The local representation of the genetic code is in terms of bits and using sequences of genetic codons as units of 6 bits. The second representation is in terms of 3-chords of light defining the allowed chords of a bio-harmony. Music expresses and induces emotions and bio-harmony would characterize a mood. Emotional intelligence would relate to this representation. Could it be that for idiot savants non-verbal emotional intelligence dominates.

The duality of these two representations of genetic code is highly analogous to the duality of momenta and position coordinates in wave mechanics. In quantum TGD this duality has as an analog $M^8 - H$ duality [L90, L91] stating that space-time surfaces can be regarded as 4-surfaces in $H = M^4 \times CP_2$ or in M^8 . $M^8 - H$ duality relates these representations. H corresponds to ordinary differential geometric space-time representation involving also the notion of field. M^8 identifiable as 8-D momentum space corresponds to non-local algebraic and number theoretic representation, which is non-local and holistic since the momenta are analogous to frequencies. Scattering amplitudes in particle physics provide an example of this representation.

Both representations can be used and it depends on the situation which representation is more appropriate. Could it be that for ordinary *resp.* emotional intelligence H *resp.* M^8 representation is more appropriate? Could one exaggerate and say that not only idiot savants but also people in timeless meditative state and experiencing no separations (produced by cognitive SFRs), and maybe also children “live” in M^8 whereas the ordinary people with their tight time schedules and busily performing comparisons “live” in H ? Momentum eigenstates are delocalized.

Are meditative states labelled by finite simple groups?

What could be the counterpart of meditative state without cognition be at the level of cognitive representations? Could it correspond to a situation in which it is not possible to create separations as decompositions to unentangled system pairs by reducing the entanglement between the factors of the Galois group G ?

This is certainly the case if G is simple, that is does not allow this factorization at all. Simple finite groups are the basic building bricks of finite groups: the classification theory for simple groups [A1] (<https://cutt.ly/Pj2i2Nx>) states that simple finite groups is cyclic and of prime order, alternating group consisting of even permutations of n objects, group of Lie type or one of the 26 sporadic groups or Tits group. The meditative states of pure consciousness would correspond to finite simple groups!

A question about possible classification of meditative states definitely raises eyebrows. But the power of mathematics is miraculous: if one agrees that thinking means SFRs (thought generates separations and comparisons) and that in meditative states thinking ceases, this is the conclusion. Rather paradoxically, the “idiot savant state” would be cognitively irreducible in the same sense as the states of Hilbert space with prime dimension do not allow a representation as entangled states. They would represent elementary particles of cognition – fundamental ideas – from which more complex thoughts are composed by performing repeated extensions. The basic advice of meditative practices is to stop thinking: maybe this is indeed the manner to achieve the state of understanding.

Part II

WATER MEMORY AND METABOLISM

Chapter 6

Homeopathy in Many-Sheeted Space-time

The claimed mechanisms of homeopathic healing and the method of manufacturing homeopathic potencies are not the only paradoxical aspects of homeopathy. Also the reported frequency imprinting and entrainment, codes based on field patterns, and associative learning of water look mysterious in the framework of standard physics.

1. Frequency imprinting and entrainment

Frequency imprinting and entrainment at preferred frequencies are believed to be fundamental for homeopathy and acupuncture. The data suggest that water builds representations for the chemicals it contains as space-time sheets containing water in liquid crystal form. These space-time sheets reproduce relevant part for the spectrum of rotational frequencies of the molecule in rigid rotor approximation. Also the mimicry of vibrational spectrum using sound waves can be considered possible. Besides LC water blobs also magnetic mirrors consisting of magnetic flux tube plus parallel MEs pop up naturally in the original model of frequency imprinting and entrainment.

The basic objection is that if the space-time sheets are in thermal equilibrium, the scenario partially fails in the case of fundamentally important rotational and conformational spectra which are in microwave region. TGD however suggests that also inherently dark variants of elementary particles, atoms, ions, and even molecules are possible. In this case various vibrational and rotational frequencies would define a hierarchy of dark energies which can be above thermal threshold. In particular, rotational and conformational microwave spectra of bio-molecules have dark counterparts with energies above the thermal threshold. Otherwise only cyclotron energies and plasma oscillation energies can be above thermal threshold at sufficiently high levels of dark matter hierarchy.

2. Scaling laws

Homeopathy seems to involve two kinds of scaling laws which seem to be closely related. What I call scaling law of homeopathy states that homeopathic frequencies appear in pairs (f_h, f_l) of high and low frequencies such that their ratio is given by $f_h/f_l \simeq 2 \times 10^{11}$. TGD approach explains this ratio predicts a generalization of the law. $v = Lf_l$ scaling law tells in TGD framework how the frequencies associated with generalized EEG code for the velocities of physiological waves and their frequencies $f_h = cf_l/v$. The general model for motor control by magnetic body predicts this scaling law.

The hierarchy of Planck constants explains this scaling law and generalizes it. The two frequencies correspond to f_l associated with dark photon with $h_{eff} = n \times h$ and to f_h associated with ordinary photon giving $f_h/f_l = n$. Bio-photons would result in energy conserving decays of dark photons to ordinary photons.

3. Dark nuclear strings as analogs of as analogs of DNA-, RNA- and amino-acid sequences and baryonic realization of genetic code

A speculative picture proposing a connection between homeopathy, water memory, and

phantom DNA effect is discussed and on basis of this connection a vision about how the tqc hardware represented by the genome is actively developed by subjecting it to evolutionary pressures represented by a virtual world representation of the physical environment. The speculation inspired by this vision is that genetic code as well as DNA-, RNA- and amino-acid sequences should have representation in terms of nuclear strings. The model for dark baryons indeed leads to an identification of these analogs and the basic numbers of genetic code including also the numbers of amino-acids coded by a given number of codons are predicted correctly. Hence it seems that genetic code is universal rather than being an accidental outcome of the biological evolution.

4. Findings of Pollack and identification of prebiotic life forms

The findings of Pollack about exclusion zones and fourth phase of water provide more detailed view about what might happen. In TGD framework exclusion zones correspond to dark $H_{3/2}O$ phase of water with every fourth hydrogen atom or proton taken to the dark flux tubes. This makes the exclusion zone negatively charged. The magnetic body of this kind of region would define fundamental representation of the magnetic body of the invader molecule. Not only cyclotron frequencies, but possibly also braiding would be represented, even 2- braiding involving reconnections. This leads to the idea that exclusion zones are primitive life forms having magnetic body containing dark matter. Most importantly, are representation of genetic code in terms of dark proton sequences would be realized at the flux tubes of the magnetic body.

5. How immune system might have evolved?

Organism or prebiotic life form living in water must recognize the invader molecule and here reconnection of the flux tubes of magnetic bodies is here the key mechanism: it would provide basic mechanism of attention and recognition. This requires that the strength of magnetic fields at flux tubes are same and organism could vary it by varying the thickness of the flux tube carrying monopole flux. This would also involve cyclotron resonance taking place simultaneously. If dark ELF photons are involved the cyclotron resonances can have energies visible and UV range characterizing bio-photons. This energy range corresponds also to excitation energies of various bio-molecules.

A further element comes from the observation that dark proton sequences could give rise to dark DNA. These sequences would reside at the flux tubes of the magnetic body associated with the exclusion zone. They would define dark variants of proteins and amino-acids. The key idea is that dark variants of amino-acid sequences would have coded not only for the braiding of the magnetic body of the invader but also for the 2-braiding (temporal development of braiding) of the magnetic flux tube patterns defining invader molecule as a dynamical process: dark proteins would mimic physically the braiding of invader molecule's magnetic body.

Dark DNA sequences would have coded this braiding symbolically and their translation to dark amino-acids would transform symbolic representation to a concrete physical one. The emergence of ordinary DNA and amino-acids would have realized the same at biochemical level and amino-acid sequences representing the invader would serve as antigens attaching to the invader molecule. Not only the pattern produced in protein folding but also the temporal pattern of protein folding would be coded by DNA.

6. Model for the homeopathy

The model of homeopathy must explain the effectiveness of homeopathic remedies manufactured by a repeated dilution and succussion. This can be understood if part of chemical involved is transformed to dark matter and is also represented by water clusters or dark super-nuclei formed from protons. This minimal representation involves thermally stable dark cyclotron frequencies. If inherently dark atoms and molecules with essentially same energy spectrum as ordinary ones are possible, also the mimicry of vibrational and rotational spectrum is possible by clusters of dark water molecules.

One must also understand why homeopathic remedies are manufactured from molecules which basically cause the symptoms to be cured. This brings strongly in mind the functioning of immune system: when the organism is exposed to the substance causing the health problem, immune system develops resistance. Maybe something similar happens in homeopathy in the sense that the homeopathic remedy representing the substance induces resistance. A representation carrying information about the biologically important aspects of the substance would be therefore

needed.

This suggests that the manufacturing of the homeopathic remedy generates replicating primitive life forms analogous to the exclusion zones. The repeated mechanical agitation could feed to the system metabolic energy and induced the formation of new exclusion zone like regions mimicking the magnetic body original invader molecule or the already existing representations of it. Even quantal evolution at the level of dark DNA could take place. The final outcome would be population of primitive life forms representing the invader. This representation would in turn induce generation of immune response.

The model should also explain the associative learning and field codes. The presence of dark matter hierarchy leads to a model for how magnetic body performs motor control using dark photons with universal energy spectrum corresponding to that for bio-photons and with wavelengths which for cyclotron photons are inversely proportional the mass of the ion. Dark photons can induce resonant communications between magnetic bodies and also excitations of biomolecules. In the original model I proposed that also dark plasmoids and their quantal plasma oscillation patterns are involved and probably this is the case. Magnetic bodies would receive sensory input from the biological body and experiences it as a kind of somatosensory representation along entire magnetic body. It would be the magnetic bodies at higher levels of dark matter hierarchy which learn rather than mere water.

Context sensitive field codes emerge naturally as codes involved with all bio-control, in particular gene expression. Spatio-temporal field patterns would correspond to the outcomes of 4-D quantum self-organization made possible by ZEO where most probable 3-surfaces are pairs of space-like 3-surfaces at the opposite ends of causal diamonds defining spatio-temporal field patterns - time evolutions of magnetic bodies. Morphogenesis would represent highest level for this kind of temporal patterns coded basically by DNA.

7. Some applications

The model of the magnetic body and the mechanism of motor control based on plasma oscillations of plasmoids can be tested by finding whether it allows to understand various enigmatic findings. Priore's machine which is a device claimed to induce a cure of cancer by somehow stimulating the immune system defines one such application. The findings of Sue Benford about intentionally produced tracks and dots in nuclear emulsions and microwave hearing and closely related taos hum define further applications. There is experimental evidence that electromagnetic stimulation can be used to transfer genetic information imprinted in field patterns between organisms belonging to different species. The idea about genes responsible for genetic self engineering and responding to field patterns representing foreign genes pops up naturally in dark matter inspired vision.

The general model for the magnetic body allows also to sharpen the model of remote mental interactions. In fact, these effects would be only a scaled-up exogenous versions of the effects appearing endogenously in cellular length scales and also in astrophysical length scales in communications between magnetic bodies and corresponding biological bodies.

The appendix of the book gives a summary about basic concepts of TGD with illustrations. Pdf representation of same files serving as a kind of glossary can be found at <http://tgdtheory.fi/tgdglossary.pdf> [L21].

6.1 General View About Homeostasis

For the benefit of the reader a general view about homeostasis a la TGD is first described before the construction of a model for homeopathy. First the general picture prior to the ideas about dark matter hierarchy is discussed and then the modifications implied by dark matter hierarchy are considered briefly.

6.1.1 Super-Conducting Part Of The Ionic Flow Circuitry

The observations described in [J28] provide important clues about the general structure of the super-conducting part of the ionic flow circuitry assumed to be realized as a fractal structure of magnetic flux tubes. The following scenario is consistent with the basic observations.

Magnetic circulation

Magnetic circulation is analogous to blood circulation and emerges during the development of the organism. Magnetic flux tubes form the super-conducting part of a many-sheeted ionic flow circuitry. Supra currents flow along magnetic flux tubes and are transformed to dissipating Ohmic currents when they flow to the atomic space-time sheets.

According to [J28], the frequencies associated with the acupuncture meridian lines remain in a good accuracy invariant during the life cycle of the organism [J28]. If the ELF frequencies correspond to magnetic transition frequencies, they characterize the thicknesses of the magnetic flux tubes carrying the ions and at least part of the magnetic flux tube circuitry could be closely related with the acupuncture meridian lines. There are very many ions and the magnetic frequency scale varies by a factor of order 100 over the periodic table. Homeopathy demonstrates that also ELF frequencies below those associated with atomic ions are important and this leads to the conclusion that also the magnetic transitions for space-time sheets containing water in liquid crystal form contribute to the ELF spectrum. The work of Mae Wan-Ho suggests a close correlation of flux tube circuitry with collagen circuitry [I136]. The DC current circuitry discovered by Becker [J25] could correspond to the dissipative part of the circuitry.

According to [J28], the endogenous frequencies vary only by ± 2 per cent. This would mean that endogenous magnetic flux tube thickness varies only by ± 1 per cent.

Frequency entrainment suggests magnetic homeostasis

Super-conducting magnetic flux tubes inside water and inside body body contain large number of ions, molecules, etc.. and there is large variety of magnetic transition frequencies which could be controlled by varying the magnetic flux tube thickness to stay in resonance with the exogenous frequency.

The phenomenon of frequency entrainment supports the notion of magnetic homeostasis. Endogenous frequencies indeed tend to follow the variation of an exogenous stimulating frequency initially sufficiently near to the endogenous frequency up to ± 30 per cent relative change after which they jump back to their endogenous values. The entrainment of the endogenous frequencies to external frequencies suggest that the thickness of the magnetic flux tubes in water and living matter is subject to a bio-control and that it makes sense to speak about magnetic homeostasis. The above data would mean that the thickness of the magnetic flux tube can change at most ± 15 per cent. The observed variation of the high-to-low frequency ratios along meridians deviation of ± 15 per cent. This would mean that the thicknesses of various magnetic flux tubes are with high accuracy scaled by a same factor in the endogenous magnetic homeostasis.

Self-organization by quantum jumps might automatically lead to the selection of preferred values of the magnetic flux tube thickness guaranteeing entrainment in healthy organism. The precise mechanism inducing the variation of the magnetic flux tube thickness remains however unidentified at this moment. The return of the entrained frequencies to their endogenous values does not seem to occur with the normal rate for electromagnetically hypersensitive persons [J28]: perhaps em hypersensitivity means that the mechanism controlling magnetic flux tube thickness does not function properly.

Why magnetic homeostasis?

There are good reasons why for the magnetic homeostasis.

1. Magnetic homeostasis with parallel MEs makes it possible for the system to entrain to the frequencies of various chemical transitions occurring in living matter. This would make possible endogenous spectroscopies allowing the organism to consciously (not necessarily at level of entire organism) detect various chemical concentrations by magnetic quantum phase transitions induced at these frequencies. Also the entrainment of neurons to external frequencies could rely on this mechanism.
2. Magnetic transitions could participate bio-control. "Stimulation of chakras" would translate to resonant generation of magnetic phase transitions at super-conducting magnetic flux tubes. If magnetic transitions affect the structure and properties of the bio-molecules, this in

turn can induce strong control effects at the atomic space-time sheets. For instance, if super-conducting enzyme molecule suffers a magnetic transition at super-conducting space-time sheet, its enzymatic properties could change dramatically. Magnetic transitions at resonance frequencies at super-conducting space-time sheets could induce protein conformations somehow. They do not directly affect net supra currents essential for ionic flow equilibrium. Spin flip could however induce change of the direction of the electric dipole moment and induce chirality changes, etc.. Conformations of enzymes could change and their catalytic properties could be affected dramatically.

3. Also non-magnetic transitions induced by MEs parallel to the magnetic flux tubes could occur coherently for BE condensates of atoms and even molecules at super-conducting space-time sheets and optimize the effectiveness of the bio-chemical control. A possible explanation for the necessity of the immune system is that quantum coherence of protein Bose-Einstein condensates is reduced if organism contains alien proteins with same function so that the rates for transformations of the protein (say enzyme) conformations at super-conducting space-time sheets are reduced.
4. Magnetic transitions for the space-time sheets containing water in liquid-crystal form and having size smaller than the transversal thickness of the magnetic flux tube have spectrum extending to $1/f = 1000$ years. This means that all biological rhythms relevant for life at the level of single organism could be coded to these structures. In particular, the representation of long term memories (not at the geometric now but at the moment of the actual event) might involve this kind of structures.

Are wormhole magnetic fields involved?

“Wormhole magnetic fields” are pairs of magnetic flux tube space-time sheets with vanishing net energy (in TGD framework space-time sheets with negative energy are possible because space-time is 4-surface rather than an abstract Riemann space) and carrying opposite magnetic fields. Wormhole contacts, whose throats carry opposite classical em charges, connect the two space-time sheets, and if they rotate, they generate opposite currents at the two space-time sheets involved in turn giving rise to magnetic fields of same magnitude but opposite sign. No elementary particles are required to generate these magnetic fields. Vacuum polarization effect is in question in a well defined sense.

At least the positive energy space-time sheet could contain supra phases of ions and an open question is whether super-conducting magnetic flux tube circuit consists of ordinary magnetic flux tubes only or whether it contains also parts which are wormhole magnetic fields. Wormhole magnetic fields could be regarded as a simulation of ordinary magnetic structures and homeopathy might involve also the generation of wormhole magnetic fields mimicking the magnetic structures associated with the homeopathic remedy. Wormhole magnetic fields might replicate and diffuse from homeopathic potency to body without any external energy feed and could be regarded as a life form of their own.

There is an obvious analogy between wormhole magnetic field and DNA double strand: similar analogy holds true for double -sheeted MEs which could also be present. Both double-sheeted MEs and wormhole magnetic fields would be structures carrying pure information.

6.1.2 How Water Represents?

The general model for how water can represent in its own dynamical structure the chemicals is inspired by various experimental findings (especially by the findings challenging the notions of ionic channels and pumps) is roughly the following.

1. The magnetic flux tube structure is fractal and thus contains flux tubes inside flux tubes and gives rise to what might be called magnetic circulation analogous to blood circulation. The magnetic field of Earth is important but not necessarily the only part of the structure. The thickness of the flux tube, and thus also magnetic transition frequency scale, is under bio-control. Also the length of flux tube is variable and under control.

2. MEs parallel to the magnetic flux tubes are also involved. The ends of magnetic flux tube could act effectively as laser mirrors and MEs would thus define zigzag path in space-time between the ends of the magnetic flux tube. Similar structures are involved with the model of long term memory and the structures in question could quite generally give rise to conscious memory in the time scale determined by the frequency involved. The characteristic frequencies associated with MEs are given by $f = c/L$, where L is the length of ME. There are thus *two branches* in the spectrum of important characteristic frequencies: magnetic transition frequencies in ELF range and the high frequency branch of the frequencies associated with MEs with lengths not above than the size of organism. For length scale of .1 meters the frequency scale of ME frequencies is of order GHz.
3. Positive/negative energy MEs could be even classical correlates for photon emission/absorption. Quite generally, MEs with typical length $L = c/f$ are presumably necessary for a complete TGD based description of atomic and molecular transitions at given transition frequency f . One can even consider the possibility that p-adic ME in presence of charged particle could transform to real ME and charged particle such that energy momentum conservation is satisfied. In this manner intention would be transformed to action at elementary particle level. One could also think that MEs at these frequencies could perform bio-control and also detect radiation emitted by various molecules.
4. Frequency imprinting and entrainment are generic phenomena. Both endogenous and exogenous frequencies can be entrained by varying the thickness and length of the magnetic flux tubes. This suggest that bio-system is performing kind of endogenous spectroscopy by detecting important bio-chemicals at magnetic flux tubes and even elsewhere. In ELF part of spectrum NMR or its generalizations to other than spin flip transitions would be involved. Also the sensing of important em frequencies as such could be performed routinely by bio-system in this manner. An interesting possibility is that also p-adic variants of MEs are involved so that this process could be seen as mimicry by singing in the same tune.
5. Weak magnetic fields affect the super currents running in the circuitry and this in turn affects dramatically the ionic concentrations at the atomic space-time sheets so that chemical control becomes possible. Magnetic transitions at super-conducting space-time sheets can affect the catalytic properties of enzymes and thus make possible more refined quantum level chemical control. Also *other* than magnetic transitions could occur coherently (rate proportional to number of ions squared) at super-conducting space-time sheets and even atomic space-time sheets and be induced by MEs at the high frequency portion of the spectrum. Perhaps the rates for the transitions inducing protein conformations affecting the catalytic properties of the protein could be optimized in this manner. The performance of this kind of bio-control at super-conducting space-time sheets would be like performing surgery inside a specialized hospital instead of doing it on the street.

The above considerations do not answer the question about the role of the atomic space-time sheets in the representations of frequencies provided by MEs and magnetic flux tubes. What this role might be is suggested by the fact that the matter at the atomic space-time sheets should have the role of an amplifier of em fields associated with MEs.

1. The generation of space-time sheets containing water in liquid crystal form with a rotational frequency spectrum mimicking that of the homeopathic potency is a further aspect of this mimicry and could amplify the otherwise weak signal provided by chemical by amplifying the em fields associated with MEs. The water domain could be also seen as a mental image (sub-self) about the chemical at atomic space-time sheet. In principle all the rigid body aspects of the molecule can be mimicked in this manner. Mimicking water domains can also control the transitions of the bio-molecules or vice versa.
2. Not only rotational spectrum but also vibrational spectrum (such as conformational vibrations of molecules) can be mimicked since any system near equilibrium reduces to a collection of harmonic oscillators: now sound waves propagating in LC water blobs would provide the representation. It is known that the water in cell interior and near to the cell membrane transforms routinely between sol and gel (LC) states in response to various stimuli: this

transformation would have interpretation as a formation of a conscious representation for something, perhaps some event or object outside the cell.

3. Note that by scaling law $f_h/f_l = 2 \times 10^{11}$, the characteristic neuronal frequency $f_l = 1$ kHz corresponds to $f_h = 2 \times 10^5$ GHz and to a ME with a length of 1.5 micro-meters, which roughly corresponds to the thickness of the magnetic flux tube. Thus kHz frequency is maximal if ME is required to extend outside the magnetic flux tube. Perhaps this ME could be involved with the sensory representations at the cell level. Note that an alternating voltage at kHz frequency is used also to generate Kirlian effect. For human vision the wave lengths of photons are in the range of $10^{-6} - 10^{-7}$ meters and corresponding ELF length scale is $10^4 - 10^5$ meters if scaling law is assumed.
4. The requirement that LC water blob has size not larger than about one micro-n implies that the lowest ELF frequency corresponds to a time period of about $T = 1000$ years so that all time scales relevant for human consciousness are covered and MEs with frequencies relevant to human long term memories can be amplified by intracellular LC water space-time sheets. If the scaling law $f_h/f_{EEG} = 2 \times 10^{11}$ is taken literally, one obtains $f_h = 20$ Hz at the upper bound: this corresponds to the lowest audible frequency which suggests that also sound waves serve representative purposes.
5. Fractality suggests that LC water space-time sheets form in turn liquid crystals in larger length scale give rise to secondary representations and that there exists entire hierarchy of these representations.

6.1.3 The Role Of Micro-Waves In Homeostasis

Plasmoids (or plasmoids) consisting of closed magnetic flux tube structures carrying supra currents plus atomic space-time sheets associated with them, are good candidates for primitive electromagnetic life-forms, in particular plasmoids identified as UFOs. It has been found that plasmoids indeed satisfy the basic definitions of a life form [I147]. Ordinary bio-matter is assumed to self-organize around these structures and nerve circuit represents a good example of a structure resulting in this manner.

Also the magnetic life forms need energy feed to self-organize and stay awake. The basic metabolic mechanism would be the same as in the case of living matter [K62]. Energetic super-conducting ions must be somehow driven from the magnetic flux tubes to the atomic space-time sheets, where they collide with atoms, ionize them, and generate visible light in the atomic transitions giving thus rise to the observed luminous phenomena interpreted as UFOs. The ions would eventually “drop” back to super-conducting space-time sheet and liberate the zero point kinetic energy as a quantum of metabolic energy defining what is often referred to as a universal energy currency. Essentially identical energetic cycle of Karma would be realized also in living matter but involve a complex molecular organization and many-sheeted current circuitry responsible for the control of homeostasis. For the proton the quantum is predicted to be of order .5 eV liberated also when a single molecule of ATP is used.

The realization of this primitive metabolic cycle requires the breaking of super-conductivity: some mechanism must generate join along boundaries bonds serving as bridges connecting magnetic flux tubes with atomic space-time sheets along their boundaries so that supra current leakage becomes possible. The gap energy of super-conductors, typically measured in 10^{-4} eV as a unit (corresponding to temperature of order Kelvin), would naturally correspond to the energy needed to build up this bond (note that the temperature at the magnetic flux tubes would be much lower). Interestingly enough, a gap energy would 10^{-5} eV corresponds to the frequency ~ 3 GHz. This suggests that micro-wave photons could induce these bridges, break super-conductivity, and induce energy feed and self-organization. A similar breaking of super-conductivity might be also involved with the driving of the super-conducting ions to the atomic space-time sheets in the living matter. Proteins could generate the needed micro-wave photons by coherently occurring conformational transitions. Also rotational transitions of clusters of water molecules could emit micro-waves and perhaps mimic and amplify the micro-waves generated by proteins.

The clusters of water molecules forming liquid crystals can mimic the conformational and rotational spectrum of various molecules, and that the ability to reproduce the rotational frequency

spectrum of the medicine molecule is an essential element of homeopathic healing. The level of self-organization of water would thus be measured by how complex mimicry it is able to perform. Why rotational micro-wave energy spectrum is so important for healing, could be understood as follows. The many-sheeted current circuitry, involving atomic space-time sheets and magnetic flux tubes and also other space-time sheets, is extremely complex control structure [K87, K86]. The continual regeneration of bridges between, say, atomic space-time sheets and magnetic flux tubes by micro-waves emitted by proteins is necessary to sustain this circuitry. An important category of diseases is due to the failure to generate the bridges between super-conducting and atomic space-time sheets so that this control circuitry suffers shortcuts. Perhaps the genetic expression of some proteins responsible for the micro-waves generating particular bridges fails.

The medicine or its homeopathic counterpart would help to generate (or even re-establish the generation of) the micro-wave spectrum responsible for the generation of the lacking bridges in the circuitry. A further piece to the puzzle comes from the scaling law of homeopathy. The law states that high and low frequencies accompany each other, the frequency ratio being $f_{high}/f_{low} \simeq 2 \times 10^{11}$ in the simplest situation (the ratio can actually vary). The TGD based interpretation is that ELF MEs are responsible for quantum entanglement in macroscopic, even astrophysical, length scales. Micro-wave MEs propagating effectively as mass-less particles along ELF MEs in turn induce self-organization by serving effectively as “food” of the plasmoidic life forms at the receiving end. This mechanism is behind both the endo- and exogenous realizations of intentions as actions, that is ordinary motor actions and phenomena like remote healing and psychokinesis. Also sensory representations at the personal magnetic canvas and magnetosphere rely on this mechanism, and in this case life-forms are mental images getting at least partially their metabolic energy from brain.

6.1.4 How The Vision About Dark Matter Hierarchy Affects The Picture?

The picture discussed in previous subsections is essentially that before the ideas about dark matter hierarchy emerged. The basic implication of the dark matter hierarchy is that there is no need to assume that temperatures at different space-time sheets are widely different since the scaling of \hbar can scale up the energies above thermal threshold. The simplest model of dark hydrogen atom however predicts that the energies of the hydrogen atom are scaled down by $1/r^2$, $r = \hbar/\hbar_0$, which means that inherently dark atoms and molecules would not be thermally stable at room temperatures.

In topological condensation of ordinary atoms and molecules at dark space-time sheets cyclotron energies and plasma oscillation energies are scaled up and can be above thermal threshold. This leads to a very restrictive model. For instance, the conformal and rotational spectra of biomolecules correspond to microwave frequencies and would be below thermal threshold and thus of no importance. This would also reduce the importance of liquid crystals known to be of crucial importance for the functioning of living matter. There is also a feeling that the role of fermionic bio-ions such as Na^+ , K^+ , and Cl^- should be more important than this picture allows.

One can however consider a modification of the notion of dark atom in which the dark energy spectra are essentially same as the ordinary ones. This would mean that the original vision about water blobs as being able to mimic molecules using their rotational and vibrational spectra is modified only by replacing these structures with their dark variants. Of course, at this stage only experiment can decide whether atoms and molecules can be inherently dark. In the following the two models of dark atom are discussed to give an overall view about what is involved.

An alternative model for inherently dark atoms

The attempts to understand dark matter hierarchy led to an alternative model of dark atoms in which the energy spectra of dark atoms and molecules are nearly the same as their ordinary counterparts.

1. The original model for dark atoms relies on the scaling of Planck constant by $r = 2^{k_d}$ at the k_d^{th} level of the dark matter hierarchy. In the case of hydrogen atom the model predicts that the energies of hydrogen atom proportional to $1/r^2$ so that dark atoms would not be thermally

stable at room temperature. In practice this would exclude dark atoms and molecules as biologically interesting inherently dark systems. The topological condensation of ordinary atoms and molecules at r -sheeted (now in the sense of “Riemann surfaces” over M^4) dark magnetic flux quanta is however possible and means scaling up of the cyclotron energy by r making possible cyclotron Bose-Einstein condensates at high temperatures identifiable as dark quantum plasmas. The same scaling occurs to the energy of dark plasma oscillations so that their energies can be above thermal threshold. Dark plasmoids and plasma oscillations are indeed fundamental in the TGD based model of quantum control in living matter.

2. One must be however very cautious in drawing conclusions since the model for the dark matter is not precise enough to exclude the possibility that the notion of dark atom and molecules makes also sense. For instance, dark atoms having ordinary size and ordinary energy spectrum could be possible if the principal quantum number n is fractionized to $n \rightarrow n/r$. The fractionization could make sense if the atomic space-time sheet is r -folded and atoms become radial anyons. The corresponding Bohr orbits would close in the radial direction only after r turns. The formation of dark atoms could be interpreted as a transition to chaos by period r -folding in radial and angular degrees of freedom. This option would differ from the first one in that radial scaling in M^4 by a factor r^2 is replaced by a radial r -folding so that the M^4 projection of dark atom has the same size as in the case of ordinary atom.

This picture is favored by the requirement that four-momenta and angular momenta remain invariant in the transition to the dark matter phase but does not conform with the first model of dark atoms which assumes that n is integer. This model was formulated before the realization of the r -fold Riemann surface like structure of dark space-time sheets following from the conservation of angular momentum.

3. Since dark atom would define a r -fold covering of M^4 , one expects a degeneracy of states corresponding to the phase factors $\exp(ikn2\pi/r)$, $k = 0, \dots, r-1$, where n labels the sheets of the r -fold covering of M^4 . The nuclei and electrons of $N \leq r$ dark atom could form many-particle states separately and fermionic statistics becomes effectively para-statistics for the resulting N -atoms. Note that the N electrons and nuclei would be in identical states in ordinary sense of the word since Bohr orbits must be identical: kind of fermionic Bose-Einstein condensates become thus possible.
4. The quantum transitions of N -atoms for $N = r$ would give rise to dark counterparts of the photons emitted in the ordinary atomic transitions. For $N \leq r$ the energies of dark photons would be N times higher than the energies liberated in the ordinary transitions. The claims of Mills [D23] about the scaling up of the binding energy of the hydrogen ground state by a square k^2 of an integer in plasma state might be understood as being due to the formation of dark $N = k^2$ -atoms emitting dark photons with k^2 -fold energies de-cohering to ordinary photons. The plasma phase would contain a fraction which is in dark plasma state. The chemistry of bio-molecules identified as N -molecules would definitely differ from the ordinary chemistry.

The fractionization $n \rightarrow n/r$ of integer n labelling vibrational modes and cyclotron states would be unavoidable. Single particle cyclotron states having $E = \hbar(k)\omega$ of the earlier picture would in this framework correspond to single particle states having $n = r$ or to $N = r$ -ion states. Fermionic $N = r$ -states are expected to have a special role since these configurations are analogous noble gas atoms with full shells of electrons and to magic nuclei with full cells of nucleons. Most biologically important ions are fermions and $N = r$ states would give rise to what might be regarded as fermionic analogs of Bose-Einstein condensates. For bosonic ions there is no restriction to the occupation numbers of r single particle states involved.

5. The phase $q = \exp(i2\pi/r)$ brings unavoidably in mind the phases defining quantum groups and playing also a key role in the model of topological quantum computation [K4]. Quantum groups indeed emerge from the spinor structure in the “world of classical worlds” realized as the space of 3-surfaces in $M^4 \times CP_2$ and being closely related to von Neumann algebras known as hyper-finite factors of type II_1 [K141]. Unfortunately, the integer n characterizing

the phase cannot be identified as r . Could it be that quantum groups emerge in two different ways in TGD framework?

If so, living matter could perhaps be understood in terms of quantum deformations of the ordinary matter, which would be characterized by the quantum phases $q = \exp(i2\pi/r)$. Hence quantum groups, which have for long time suspected to have significance in elementary particle physics, might explain the mystery of living matter and predict an entire hierarchy of new forms of matter.

Are both options for dark matter realized?

For $N = r$ molecules which dark photons emitted in the rotational and conformational transitions would be above thermal threshold. It is of course quite possible that both options are realized. The fact that also fermionic ions (such as Na^+ , K^+ , Cl^-) are important for living system suggests that this is the case. This would also provide a justification for the hypothesis that microtubular conformations represent bits and allow conformational dynamics to serve as metabolic controller by providing microwave dark photons with energies above thermal threshold.

As demonstrated in [K68], the notion of N -particle leads to an amazingly elegant model for the lock and key mechanism of bio-catalysis as well as the understanding of the DNA replication based on the spontaneous decay and completion of fermionic $N < r$ -particles to r -particles. Optimal candidates for the N -particles are N -hydrogen atoms associated with bio-molecules appearing as letters in the “pieces of text” labelling the molecules. Lock and key would correspond to conjugate names in the sense that N_1 and N_2 for the letters in the name and its conjugate satisfy $N_1 + N_2 = r$: as the molecules combine, a full fermion shell represented by r - fermion is formed.

6.2 TGD Based Model For Homeopathy

Homeopathy is regarded by skeptics as a fringe science, kind of promised land of crackpots. My own views about homeopathy changed after I heard the excellent lecture of Cyril Smith in Liege about frequency imprinting and entrainment as mechanisms of homeopathy [J28]. After that I learned about the work of Benveniste [I74, I75] and encountered once again the pattern which I had encountered so many times before. When empirical discovery does not fit the dogmas of the reductionistic science, it is simply forgotten and the unlucky experimentalist is labeled as a swindler or crackpot.

6.2.1 Basic Claims About Homeopathy

The basic assumption of homeopathy is that the homeopathic remedy manufactured from the substance causing the illness also heals the illness. The preparation of the homeopathic remedy occurs by a repeated dilution so that for instance 1 part of homeopathic remedy already obtained is diluted in 99 parts of water. The dilution can be continued arbitrarily many times, say 30 times so that the ratio of substance to water is 10^{-60} : obviously no molecules of the original substance can be present anymore in the probabilistic sense if one accepts the standard view about space-time.

The notion of water memory [I74] crucial for the explanations of acupuncture and homeopathy has received a considerable empirical support quite recently [I44]. It seems that basic mechanisms of both homeopathy and acupuncture are frequency imprinting and entrainment. Somehow water learns the some fundamental frequencies characterizing the molecules of the homeopathic remedy during the manufacturing process and when it has learned these frequencies it acts as the desired healing effect. Even more: just this frequency imprinting of water without any need for the remedy could be enough to achieve the healing effect.

6.2.2 Frequency Signatures For The Homeopathic Remedies And Endogenous Frequencies In Acupuncture

The homeopathic remedies seem to be characterized by frequencies varying in the range containing at least the range $10^{-3} - 10^9$ Hz suggesting that electromagnetic fields at specific frequencies characterize the homeopathic remedy. These frequencies can be imprinted into water and also

erased. The imprinting of frequencies is induced by the presence of the homeopathic potency or by irradiating pure water by using either the ELF or far infrared frequencies associated with the potency. Very importantly, the removal of Earth's magnetic field erases the imprinted frequencies [J28].

The frequencies appear as pairs (f_h, f_l) of high and low frequencies in the sense that the imprinting of f_h implies the imprinting of f_l and vice versa [J28]. The first branch is at GHz range: in particular the frequencies 2.664 GHz, 1.42 GHz (21 cm line of hydrogen) and 384 MHz have unexpected properties. The second branch of frequencies is in the ELF range, in particular Schumann frequency 7.8 Hz accompanies 384 MHz. The ratio of high and low frequencies is in good approximation constant and equal to $f_h/f_l = 2 \times 10^{11}$: this result gives strong constraint on possible models.

The studies of acupuncture support the existence of certain highly coherent endogenous frequencies [J28] associated with the acupuncture meridians at which em radiation has strong effects. Also these frequencies appear as pairs and the ratio $f_h/f_l \simeq 2 \times 10^{11}$ is constant over all acupuncture meridians with a deviation of ± 15 per cent. The fact that these frequencies can entrain to exogenous frequencies suggests a mechanism of homeopathy based on entrainment and mimicry. It would be the characteristic frequencies associated with the homeopathic potency molecule, which would help to achieve the healing effect rather than the chemical structure of the potency molecule.

Quite generally, frequency imprinting and entrainment could be a basic representational mechanism in living matter. The important chemicals present in living matter would be represented by their frequencies and water would construct representations. These representations can explain why bio-system can recognize also chemicals usually not present in organism (such as poisonous molecules).

6.2.3 What Could Be The Mechanism Behind The Homeopathic Healing

Both the claimed healing using the agent causing the disease and the manufacturing process seemingly removing every trace of the remedy are paradoxical enough to induce strongly emotional reactions in the average skeptic. The notions of many-sheeted space-time (see **Fig. <http://tgdtheory.fi/appfigures/manysheeted.jpg>** or **Fig. 9** in the appendix of this book) and dark matter hierarchy however suggest a rational explanation for these claims. Several mechanisms can be imagined and I have indeed done this before finding the most convincing option.

Bose-Einstein condensation of molecules of homeopathic remedy to magnetic flux tubes as a basic mechanism

The manufacturing of the homeopathic remedy could induce dropping of some fraction of the homeopathic remedy to magnetic flux tubes of the Earth's magnetic field.

In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant \hbar_{eff} so that cyclotron energy would be liberated. In the following only the "dropping" option is discussed.

This assumption conforms with the crucial role of the Earth's magnetic field in the erasure of the imprinted frequencies. Also the importance of 7.8 Hz Schumann frequency [J28] can be understood.

If the molecules in question are bosons or if they combine with some other particles to form bosons in water environment, they can form Bose-Einstein condensates in cyclotron states. At $k_d = 40$ level of dark matter hierarchy they cyclotron energy scale would be above the thermal threshold for cyclotron frequencies above 1 Hz: the charge/mass ratio corresponds to that for DNA. Note that the hypothesis is $\hbar_{eff} = n\hbar$, where n is product of distinct Fermat primes and power 2^{k_d} .

Could protonic super nuclei perform mimicry of ions?

One of the first discoveries in the process leading to the understanding of dark matter was the direct evidence for the fact that one fourth of protons of water is in dark phase [D35, D34, D46, D24] in time scale of atto-second (these protons are not visible using neutron diffraction or electron scattering). This phase could correspond to some level of dark matter hierarchy.

The simplest model for the dark phase [K45] is as “super nuclei” formed by closed protonic strings (for the analogous model of nuclei see [K116]) with nearby protons connected by color bonds with exotic dark quark and anti-quark at ends of the bond. These protonic strings can develop also exotic em charge when the quark and anti-quark at the ends of the bond are replaced by u and \bar{d} or d and \bar{u} . Thus a protonic super-nucleus containing A protons with a proper exotic charge can mimic ion with mass number A and charge Z .

Dark protonic super-nuclei could perform mimicry of those characteristics of molecules which are crucial for the macroscopic quantum coherence. Frequency imprinting and entrainment would be based on the formation of protonic super-nuclei plus magnetic homeostasis allowing to vary the value of the magnetic field around the nominal value $B_E = .5$ Gauss in such a way that entrainment is achieved for almost any ELF frequency.

Conservation of the magnetic flux implies that the variation of field strength corresponds to the variation of the thickness of the magnetic flux tube. Magnetic homeostasis could therefore be regarded also as a motor action of the magnetic body containing dark matter and to some extent behaving like an intelligent conscious system. The magnetic flux quanta assignable to the homeopathic potency would carry the information about the molecules of the homeopathic remedy. Also p-adic scaling of flux tube dimensions by scaling factor which is power of $\sqrt{2}$ can be considered.

Could also clusters of water molecules perform mimicry?

Dark protons are not the only option. The original proposal was that clusters of water molecules are ideal for mimicking cyclotron, rotational, and vibrational spectra of molecules. The recent view about dark matter suggests that the internal properties of particles are unaffected in the dropping to r -fold magnetic flux tubes so that only cyclotron energy spectrum is scaled by r and can be thermally stable. Hence water molecule clusters could also mimic molecules. Without magnetic homeostasis the accuracy of the mimicry would not be very impressive since mass number would be a multiple of 18. For heavy molecules the relative accuracy would be $\Delta f_c/f_c = 18/A$ and could be compensated by the control of magnetic field strength.

Homeopathic healing mechanism as sweeping of harmful molecules to magnetic flux quanta?

Also the homeopathic healing mechanism could be understood. Usually the immune system prevents the access of the harmful molecule or organism to the system by chemical means. Also in the homeopathic healing similar elimination mechanism would work but now magnetic body would perform the elimination. One can imagine several mechanisms. The harmful molecules could be simply dropped to the magnetic flux quanta. The dropping of these molecules would liberate zero point kinetic energy (which brings in mind the old saying “the disease that does not kill you, strengthens you!”), and if the process involves emission of photons with frequencies f_h and f_l , the rate of the process would be enhanced by the presence of the Bose-Einstein condensates of dark photons of frequency f_l emitted in cyclotron transitions by the standard mechanism of induced emission. It would not matter whether the Bose-Einstein condensate of ELF photons causing the induced dropping is generated by the molecules of homeopathic remedy or by the protonic super-nuclei mimicking them.

Stealing of the magnetic bodies of molecules

If magnetic bodies of harmful molecules are responsible for the harmful effects, then it would be enough to steal magnetic bodies of the harmful molecules and provide clusters of water molecules with them. The shaking of the water in the manufacturing of the homeopathic remedy would facilitate this process. This option allows to understand the fact that the presence of biomolecules can be mimicked by using suitable patterns of low frequencies identifiable as cyclotron frequencies.

The domains of water with size scale of 10 nm proposed by Smith could be the thieves of the magnetic coats defining the biological role of the molecule. This option is definitely the most elegant and minimal one and seems to explain what is known about homeopathic action and water memory.

6.2.4 TGD Counterparts For The Propagation And Diffusion Of Coherence

Cyril Smith [J28] assigns the endogenous frequency pairs (f_h, f_l) with the coherent domains of water with size of 75 nm interacting with external em fields as coherent units. The origin of the scaling law $f_h/f_l = 2 \times 10^{11}$ claimed by Smith has been discussed in previous section. These coherent domains are predicted by the theory of Giudice and Preparata [D30]. On basis of empirical data Smith associates two kinds of dynamical phenomena to the coherence regions: diffusion of coherence with low velocity and propagation of coherence with light velocity.

On dimensional grounds one expects that for a coherent domain of size L dispersion relation for the low velocity excitations (not only diffusion of coherence) could be given by the scaling law $v \sim Lf$. According to Smith the observed diffusion velocities are of order few m/s $\sim m/s$ and of the same order of magnitude as nerve pulse conduction velocity and phase velocities for EEG waves. From this the size of coherent domains for the high frequency branch would be of the same order as that predicted for the coherence domains of water. For the low energy branch the size of the coherence domains would be of order .1 m.

The $v = K$ relationship proposed by Smith is of the same form as the scaling law discussed in the previous section and representing the coding of generalized EEGs to the velocities of physiological waves. In TGD framework the counterparts of these domains would be various linear structures, say space-time sheets formed by water in liquid crystal form. The propagation of coherence with light velocity would correspond to the propagation of the classical signal inside ME whereas the diffusion of coherence would basically correspond to the phase velocity assignable to ME in direction along the linear structure and fixed by the boundary condition so that it obeys the generalization of the scaling law from its original form $v = Lf_l$ to $v = Lf_l/n_h$. f_h would be given by $f_h = (c/v) \times f_l$.

6.2.5 Frequency Imprinting And De-Imprinting

In the following a more detailed comparison of TGD based model with the data discussed in [J28] is carried out. The effect of several methods allowing frequency imprinting and erasure could be understood if imprinting involves the variation of thickness of magnetic flux tubes carrying super-conducting ions.

Some facts about imprinting

I learned the basic facts about frequency imprinting from Cyril Smith's excellent lecture in Liege.

1. Cyril Smith represents detailed empirical data about n-alkane imprinting. In this case ELF frequencies were in Hz range and the ratio of the high and low frequencies was roughly 2×10^{11} as also in other experiments. This is consistent with the assumption that cyclotron frequencies serve as a representation of the molecule.
2. Smith has studied also frequency memory of bulk water (no potency present) in ELF frequency range .001 – .01 Hz. Bulk water showed resonances between 200 MGz and 2GHz with a mean frequency ratio of about 2×10^{11} as also in case of n-alkanes. If very low ELF frequencies correspond to magnetic transition frequencies in Earth's magnetic field, then the atomic numbers of the space-time sheets involved must be quite high: 10^{-3} Hz corresponds to $A = 3 \times 10^5$ and thermal stability of cyclotron energies requires at least $k_d = 53$ level of the dark matter hierarchy.
3. ELF frequency imprinting by frequency f_l was also found to induce splitting $f \rightarrow f \pm f_l$ of other inherent ELF frequencies associated with water. A similar splitting was observed in high energy branch. The explanation is that the resulting MEs interact with the MEs

associated with these frequencies and induce amplitude modulation. Interaction could be due to MEs inside MEs mechanism.

4. There might be a connection with the work of Gariaev's group [I82] demonstrating that the irradiation of DNA with a coherent light generates radiation at radio frequencies discussed in [K62]. The method inducing these radio frequencies is based on the use of two orthogonally polarized laser beams interacting with DNA in liquid crystal state and can be also used to detect imprinted frequencies [J28].

Frequency imprinting of "clean" water

Typical example of imprinting involves the transfer of imprinted frequencies through the glass of a vial containing "clean" (no chemical impurities nor imprinted frequencies) water immersed to the imprinted water serving as the frequency source. Higher ELF frequencies are transferred quickly whereas the transfer of the low frequencies can take hours or even days [J28]. The vial could be also in the proximity of the frequency source (homeopathic potency, imprinted water, or oscillator). The succussion of the vial or a brief application of the field of a strong permanent magnet allows the transfer of frequencies. The transfer of frequencies of body to a vial of "clean" water is possible by a direct contact, say by holding the vial in hand. Succussion also helps the transfer.

Several questions relate to the dynamics of the magnetic flux sheet structures.

1. Do the flux structures exist already before imprinting or are they dynamical? Can one even speak about the growth of these structures from source to the imprinted system? The general model for quantum control and communications between magnetic and biological body predicts that magnetic body is dynamical and grows during the development of individual. Thus flux quanta could penetrate/diffuse/grow from the imprinted water to the interior of the glass seal. This means also the transfer of the magnetic transition frequencies.
2. High frequencies are reported to penetrate quicker than slow frequencies [J28]. If magnetic flux quanta penetrate to the imprinted system and homeostatic variations of the flux tube area keeping the flux constant are possible, the question transforms to a new form. Why thin magnetic flux tubes carrying strong magnetic fields and high frequencies penetrate quicker than the thick magnetic flux tubes carrying weak magnetic fields? naïve geometric intuition suggests an answer here. There are several possibilities: simple dimensional analytic argument $T \propto 1/f$ or equivalently $T \propto 1/f_c$. If the time of transfer is proportional to the p-adic time scale one would have $T \propto T(k) \propto 1/\sqrt{f_c}$ (this would mean a variation by factor of 10^6 in the range $10^{-3} - 10^9$ Hz).

There is also a list of question about the imprinting using arbitrary frequency source and frequency.

1. Does the magnetic body of the source represent the frequency of the source somehow? Is this magnetic body connected to the Earth's magnetic body? Is the presence of water really necessary? Are dark proton super-nuclei present also now and do they originate from the magnetic body of Earth? Is it really possible to imprint arbitrary frequencies?
2. The frequencies should be assignable to dark photons. Hence the question arises whether the emission of ordinary photons is accompanied by emission of dark photons represented by r -folded MEs. Are ordinary photons transformed with some rate to dark photons by the reversal of coherence phase transition. Is this phase transition de-coherence phase transition for phase conjugates of dark photons?
3. Do the magnetic flux quanta perhaps form closed flux tube structures connecting the source and imprinted water? This is actually suggested by the reported Aharonov-Bohm effect [J28], which would be due to the modification of vector potential along a closed magnetic flux circuit.

Erasing the frequency imprinting

According to [J28], the removal of Earth's magnetic field by surrounding the imprinted water by a metallic container removes the imprinting provides very strong support for the fundamental role

of Earth's magnetic field. This however forces to consider critically the idea about r -folded dark magnetic flux quanta since the removal of also the r -fold dark variants of its flux quanta. This is frustrating but one must humbly accept the fact that the model for dark matter at space-time level is far from being final, and it is rather easy to end up to the garden of endlessly branching paths.

Also heating is reported lead to both appearance and disappearance of imprinted frequencies [J28]. The thermal instability conforms with the assumption that dark matter with large value of Planck constant and ordinary matter can be in thermal equilibrium: in the original framework it was assumed that larger space-time sheets are at so low temperatures that cyclotron energies are above thermal threshold.

The effect of the heating could have several explanations.

1. The simplest implication of heating is that cyclotron energies in question remain below thermal threshold and cannot anymore affect the behavior of the bio-matter. Heating can induce de-coherence phase transition of photons to ordinary ones so that the Bose-Einstein condensates of photons crucial for the effectiveness of homeopathic potency are lost temporarily. This could be tested by heating the homeopathic potency and finding whether its effect disappears. The re-appearance of imprinted frequencies seems more difficult to understand, at least if they correspond to cyclotron energies below thermal threshold.
2. Heating could also affect magnetic flux quanta, say decompose $r = 2^{k_d}$ -folded flux quanta to 2 flux quanta at level $k_d - 1$ for which cyclotron photons have sub-thermal energies. Heating can induce split flux tubes between space-time sheets of ordinary matter and magnetic flux quanta.

According to [J28] it is also possible to hide imprinted frequencies by succussing the vial on one side of an oscillator output coil. My guess for "hide" is that the imprinted frequencies are not lost permanently and can be re-established. If the Bose-Einstein condensates of dark photons are lost temporarily but the dark protonic super-nuclei or water molecule clusters responsible for the mimicry remain intact, the frequencies would be indeed "hidden".

The effect of dilution to the imprinted frequencies

The effect of dilution can alter the imprinted frequency [J28].

1. First example

In the first example $f = 1$ Hz was imprinted by succussion. Then the solution was diluted serially by a dilution factor $D \equiv 1/p = 10$. $f = 1$ Hz remained but after a succussion it disappeared and was replaced by 10 Hz. More generally, the imprinted frequency does not follow in a continuous manner the dilution factor but changes in a stepwise manner. The fact that cyclotron frequencies of DNA sequences are around 1 Hz whereas 10 Hz corresponds to alpha band containing the cyclotron frequencies of most bosonic ions [K44] might have some significance in this special case.

One can imagine two different explanations for the replacement of 1 Hz frequency with 10 Hz frequency.

1. The protonic super-nuclear (closet string like structures) having 1 Hz as cyclotron frequency would contain 300 dark protons. It could happen that these strings are unstable against the decay to super-nuclei with 30 dark protons expected to be present since frequencies in alpha band are certainly present at magnetic flux tubes of Earth. The analog of induced emission due to presence of 10 Hz dark photons would increase the rate for the decay process induced by succussion.
2. Frequency imprinting could increase the area of some flux quanta of Earth's magnetic field by a factor of 10 and thus lower the value of the magnetic field and cyclotron frequency from 10 Hz to 1 Hz so that ions in alpha band could be responsible for the frequency imprinting. The increase of the thickness by factor 10 could involve the p-adic scaling up of the thickness of the flux sheet by a factor 8 ($k = 169 \rightarrow 175$ or $k = 151 \rightarrow 157$) followed by a continuous increase of the thickness by a factor $5/4$. Succussion could bring the magnetic flux return to

the ordinary stable state corresponding to ~ 10 Hz cyclotron frequency for bosonic ions. For this option the effectiveness of homeopathic potency is not lost unlike for option 1).

2. Second example

In the second example 1 Hz is stable for a dilution factor $D = 1.4$ but for a dilution factor 1.5 it changes to 1.5 Hz.

1. The instability of $A = 300$ super-nuclei against decay to $A = 200$ perhaps mimicking some important ion (actually Gold ion Au^+ for $B_E = .5$ Gauss) could be in question. In this case the homeopathic efficiency of the potency is lost.
2. 1.5 is so near to $\sqrt{2} \simeq 1.414$ that one cannot avoid the question whether some kind of 2-adic effects are involved. The transition could reduce the thickness of the flux sheet by a factor $1/\sqrt{2}$, say in $k = 169 \rightarrow 168$ or $k = 151 \rightarrow 150$ p-adic transition. The efficiency of the homeopathic potency would not be lost. The stable magnetic field strengths for flux quanta would be piecewise constant functions of D reduced by a $1/\sqrt{2}$ -factor at $D/D_0 = \sqrt{2}^n$: this for sufficiently small values of D . If the energy of the magnetic flux tube is invariant in the scaling then also its length varies as $L \propto D$ for small enough values of D . Similar plateau effects suggesting underlying 2-adicity [K82] have been found to be associated with the intensity of sensation as a function of stimulus [J77]. If the intensity of sensation is coded to ELF frequency this effect could perhaps be understood.

3. Other strange findings

Also other strange findings are reported in [J28]: for instance, no frequency at all was imprinted for the dilution factors in the range 13-19 when starting from an imprinted frequency of 1 Hz. If these findings represent reality, the rate for the formation of the mimicking structures depends on the density of existing representatives and this range of dilution factors would represent kind of a transition zone between two kinds of situations allowing stable imprinting.

The rate for the formation of mimicking structures is enhanced by the presence of Bose-Einstein condensates of photons (the analog of induced emission). Destructive interference effects for dark photons from Bose-Einstein condensates of disjoint flux quanta could however reduce this effect. For sufficiently large values of D the destructive interference effects of photons from different flux quanta would not be significant. For small values of D the flux quanta could fuse to form single structure guaranteeing the absence of destructive interference effects. There could however exist a transition region in which destructive interference are important and reduce the rate for the formation of mimicking structures: perhaps this region corresponds to D in the range 13-19.

Biological Aharonov-Bohm type effects

Even the vector potential of a vanishing magnetic field can affect the state of living matter and water. An example is provided by a ferrite toroidal coil containing its magnetic field inside the toroid [J28]. This can be understood as follows.

Suppose that there exist closed flux tubes or more general flux quanta connecting the frequency source and the vial containing the imprinted water. The non-vanishing vector potential of the ferrite toroid in the exterior of the toroidal coil affects the vector potential along these flux tubes and thus also the wave functions of the super-conducting ionic BE condensates at the closed flux tubes. The condition for this is that the closed magnetic flux tubes traversing from the source of frequencies to the vial of the clean water are linked with the toroidal coil so that magnetic flux through the surface bounded by the closed magnetic flux tube equals to the magnetic flux carried by the coil.

The vector potential A appearing in the quantization conditions for the magnetic flux

$$\oint (p - eA) dl = n \times 2\pi$$

for a linked loop is affected by the toroidal magnetic field since the loop integral is changed by the toroidal magnetic flux. This means that the momentum p of the super-conducting ion changes

for this kind of magnetic flux loops going from the frequency source to the clean water. Thus ionic supra-currents change so that the ionic concentrations and homeostasis at the atomic space-time sheets are affected in case of living matter. Both the source and vial of clean water are “magnetically entangled” in this kind of situation. An interesting question is what effects this kind of a toroid placed between two living organisms could induce. Note that for two toroidal coils with opposite current directions these effects should cancel out.

Does a critical dilution factor exist?

The dilution ratios used correspond to powers of 10: $p = 1/10^k$, $k = 1, 2, 3, \dots$. This is a mere convenient convention. There should however exist some critical dilution ratio p below which the rate for the formation mimicking molecules, be they water molecule clusters stealing the magnetic bodies of molecule or protonic super nuclei, is too low.

Similar critical ratios are encountered in the percolation of liquid to a porous substance: when the volume fraction of the wetted pores is overcritical the entire material gets wet. The strong mixing of the water could be seen as a way to optimize the potentiation. It could also enhance the rate of dropping of protons to the magnetic flux quanta.

1. For instance, suppose that diluted potency generates at each step of the process dark super-nuclei (dark protonic strings with mass number A and charge Z) mimicking the already existing super-nuclei mimicking the original molecules. If the presence of the already existing super-nuclei enhances the rate of this process as it does in induced emission so that Bose-Einstein condensation is the end step of the generation of the super-nuclei, a lower bound for the dilution factor emerges.
2. In the case of water molecule clusters stealing magnetic bodies, the critical dilution ratio would have much simpler interpretation since the rate for the loss of magnetic bodies is proportional the density of actual molecules. If so then the long sequence of dilutions would not have considerable effect. Situation could change if the magnetic bodies can replicate. This kind of replication must take place in cell division but whether it can happen under much more primitive conditions is unclear.

6.2.6 A Possible Realization Of Water Memory

The Benveniste's discovery of water memory [I74, I75] initiated quite dramatic sequence of events. The original experiment involved the homeopathic treatment of water by human antigene. This meant dilution of the water solution of antigene so that the concentration of antigene became extremely low. In accordance with homeopathic teachings human basophils reacted on this solution.

The discovery was published in *Nature* and due to the strong polemic raised by the publication of the article, it was decided to test the experimental arrangement. The experimental results were reproduced under the original conditions. Then it was discovered that experimenters knew which bottles contained the treated water. The modified experiment in which experimenters did not possess this information failed to reproduce the results and the conclusion was regarded as obvious and Benveniste lost his laboratory among other things. Obviously any model of the effect taking it as a real effect rather than an astonishingly simplistic attempt of top scientists to cheat should explain also this finding.

The model based on the notion of field body and general mechanism of long term memory allows to explain both the memory of water and why it failed under the conditions described.

1. Also molecules have magnetic field bodies acting as intentional agents controlling the molecules. Nano-motors do not only look co-operating living creatures but are such. The field body of the molecule contains besides the static magnetic and electric parts also dynamical parts characterized by frequencies and temporal patterns of fields. To be precise, one must speak both field and relative field bodies characterizing interactions of molecules. Right brain sings-left brain talks metaphor might generalize to all scales meaning that representations based on both frequencies and temporal pulse with single frequency could be utilized.
2. The effects of complex bio-molecule to other bio-molecules (say antigene on basofil) in water could be characterized to some degree by the temporal patterns associated with the dynamical

part of its field body and bio-molecules could recognize each other via these patterns. This would mean that symbolic level in interactions would be present already in the interactions of bio-molecules. Cyclotron frequencies are most natural candidates for the frequency signatures and the fact that frequencies in 10 kHz range are involved supports this view.

3. The original idea was that water molecule clusters are able to mimic the bio-molecules themselves -say their vibrational and rotational spectra could coincide with those of molecules in reasonable approximation. A more natural idea is that they can mimic their field bodies. Homeopathy could rely on extremely simple effect: water molecule clusters would steal the magnetic bodies of the molecules used to manufacture the homeopathic remedy. The shaking of the bottle containing the solution would enhance the probability for bio-molecule to lose its magnetic body in this manner. For instance, water could produce fake copies of say antigens recognized by basophils and reacting accordingly if the reaction is based on interaction with the magnetic body of the antigen.
4. The basic objection against this picture is that it does not explain why the repeated dilution works. Rather, it seems that dilution of molecules reduces also the density of mimicking pseudo-molecules. Even more, the potency of the homeopathic remedy is claimed to increase as the dilution factor increases. Also alcohol is used instead of water so that also alcohol must allow homeopathic mechanism. (I am grateful for Ulla Matfolk for questions which made me to realize these objections).
 - (a) The only way out seems to be that the magnetic bodies or water molecule clusters having these magnetic bodies can replicate. The shaking of the remedy could provide the needed metabolic energy so that the population of magnetic bodies grows to a limiting density determined by the metabolic energy feed. In principle it would be possible to infect unlimited amount of water by these pseudo-molecules. When in bottle the population would be in dormant state but in the body of the patient it would wake up and form a population of molecular actors and stimulate the immune system to develop immune response to the real molecule.
 - (b) The potency of the homeopathic remedy is claimed to increase with the increased dilution factor. This would suggest that the continued dilution and shaking also increases the density of pseudo molecules, perhaps by feeding to the system metabolic energy or by some other mechanism.
 - (c) Also magnetic bodies must replicate in cell replication and their role as intentional agents controlling bio-matter requires that this replication serves as a template for biochemical replication. One can indeed interpret the images about cell replication in terms of replication of dipole type magnetic field. This process is very simple and could have preceded biological replication. The question is therefore whether water is actually a living system in presence of a proper metabolic energy feed. Also the water's ability near critical point for freezing to form nice patterns correlating with sound stimuli might be due to the presence of the molecular actors.
 - (d) This picture fits nicely with the vision that evolution of water in this kind of life form might have happened separately and that pre-biotic chemical life forms have formed symbiosis with living water [K49, K50]. In the model of DNA as topological quantum computer [K3] the asymptotic self organization patterns of water flow in the vicinity of lipid layers indeed define quantum computer programs by inducing the braiding of the magnetic flux tubes connecting DNA nucleotides to lipids so that this symbiosis would have brought in new kind of information processing tool.
5. The magnetic body of the molecule could mimic the vibrational and rotational spectra using harmonics of cyclotron frequencies. Cyclotron transitions could produce dark photons, whose ordinary counterparts resulting in de-coherence would have large energies due to the large value of \hbar and could thus induce vibrational and rotational transitions. This would provide a mechanism by which molecular magnetic body could control the molecule. Note that also

the antigenes possibly dropped to the larger space-time sheets could produce the effect on basophils.

6. There is a considerable experimental support for the Benveniste's discovery that bio-molecules in water environment are represented by frequency patterns, and several laboratories are replicating the experiments of Benveniste as I learned from the lecture of Yolene Thomas in the 7:th European SSE Meeting held in Rörös [J45]. The scale of the frequencies involved is around 10 kHz and as such does not correspond to any natural molecular frequencies. Cyclotron frequencies associated with electrons or dark ions accompanying these macromolecules would be a natural identification if one accepts the notion of molecular magnetic body. For ions the magnetic fields involved would have a magnitude of order 0.3 Tesla if 10 kHz corresponds to scaled up alpha band. Also Josephson frequencies would be involved if one believes that EEG has fractally scaled up variants in molecular length scales.

Consider now the argument explaining the failure to replicate the experiments of Benveniste.

1. The magnetic bodies of water molecules need metabolic energy for communications with their "biological body" using the fractally scaled analog of EEG. There is no obvious source for this energy in water. The model for protein folding and DNA as topological quantum computer assumes that magnetic flux tubes connecting subject person and target of directed attention serve as correlates for directed attention at the molecular level [K3, K7]. This should be true also in macroscopic scales so that the experimentalist and the bottle containing the treated water should be connected by magnetic flux tubes. If experimenter has directed his attention to the bottle of water, the resulting magnetic flux tubes could allow a transfer of metabolic energy as a radiation along massless extremals parallel to the flux tubes and defining TGD counterparts of Alfvén waves. Experimenter's strong motivation to replicate experiments would help to realize the transfer of the metabolic energy. Experimenters not knowing, which bottles were treated did not have these flux tube bridges to the bottles, and were not able to provide the needed metabolic energy, and the magnetic bodies of antigenes failed to generate the cyclotron radiation making them visible to the basophil.
2. If this interpretation is correct, then Benveniste's experiment would demonstrate besides water memory also psychokinesis and direct action of desires of experimenters on physics at microscopic level. Furthermore, the mere fact that we know something about some object or direct attention to it would mean a concrete interaction of our magnetic body with the object. The so called phenomenon of psi track [J118] provides additional support for this conclusion.

6.2.7 Could Virtual DNAs Allow A Controlled Development Of The Genome?

The fundamental question in the evolution biology is the question about the interaction between genome (G), phenotype (P), and environment (E).

1. The standard dogma is that the information transfer from G to P is unidirectional and that environment acts on G by inducing random mutations of G , from which E selects the lucky survivors as those with the best ability to reproduce. Lamarckism [I17, I54, I76] represents a deviation from standard dogma by assuming direct information transfer from E to G .
2. Genetic expression is controlled by environment, at least by silencing [I17], which is like selecting only few books to be read from a big library. Cell differentiation represents basic example of selective gene expression. DNA methylation and transposition are accepted to reflect information transfer from E to G , perhaps via P . These modifications are believed to be short lasting and not transferred to the offspring since it is difficult to imagine a mechanism transferring the mutations to the germ cells. There is however also evidence that epigenetic information transfer takes place [I158]: this transfer would be selective expression of genes of germ cells rather than that of modified genes.

3. There are findings challenging the dogmas of static genome and random mutations. The cells of the immune system remodel their genes coding for antibodies capable of recognizing large variety of antigens. There is quite recent finding [I88] revealing major genetic differences between blood and tissue cells. There are also mutations due to jumping genes - mobile elements of DNA known as LINE-1 elements usually regarded as junk DNA whose portion from genome increases as one climbs up along the evolutionary ladder. In mice jumping genes are limited to brain and germ cells: this is easy to understand since in organs like heart and lungs this kind of mutations would be fatal. Second recent discovery is that there is a high diversity of human brain cells believed to be due to the jumping genes [I50]. That brain cells would be producing with a high rate junk DNA is not an idea which would make me shout "Eureka!"
4. The question remains whether the $G \rightarrow P - E$ actually could complete to a closed loop $G \rightarrow P - E - G$ so that genome could directly respond to the changing physical environment and could transfer the successful response to the next generation [I54].

Could genome be developed like computer hardware?

In TGD framework the sequence $G \rightarrow P - E$ is replaced with a closed loop $G - P - M - E$ to which E is attached at P by bidirectional arrow (organisms do also modify their environment actively). Magnetic body thus controls genome and receives information from cell membrane (P). The hierarchy of genomes (super-genome, hyper-genome, ...) corresponding to the different levels of dark matter hierarchy allows this loop to be realized in different scales rather only at the level of single cell.

The question is whether the magnetic body of organism or higher level magnetic bodies could modify genomes, super-genomes, and hyper-genomes directly, perhaps by generating mutations of the genome in a short time scale; by monitoring how genetically modified organism survives in the environment; and -if the outcome of the experiment is successful - replacing the corresponding portion of DNA with the modified DNA both in ordinary germ cells. One can even ask whether the abstract model of the external environment provided by the internal chemical milieu might be mimicked by water magnetic bodies of water molecule clusters and provide a virtual world testing ground for a search of favorable mutations.

In DNA as a TQC vision essentially the development of a new computer hardware would be in question, and should take place in a controlled manner and involve an experimentation before going to the market rather than by random modifications taking place in computer CPUs. Second basic aspect of DNA as TQC paradigm is that water and bio-molecules live in symbiosis in the sense that self organization patterns of the cellular water flow define the TQC programs. The following first guess for how the development of computer hardware might be achieved is just a first guess but might have something to do with reality.

1. What would be needed is a mechanism generating rapidly modifications of DNA. The mutations should be carried out using a kind of virtual DNA mimicking all the essential aspects of the symbolic dynamics associated with DNA. The magnetic bodies of DNA consisting of flux tubes connecting the nucleotides of DNA strands to cell membrane satisfy these conditions since A, T, G, C is coded to exotic light quarks u , d and anti-quarks \bar{u} , \bar{d} at the ends of flux tubes [K3]. DNA nucleotides could be replaced with clusters of water molecules but also other options can be imagined. Note that it does not matter when one speaks of mimicry of RNA or DNA molecules.
2. If the proposed model of the phantom DNA and homeopathy has something to do with reality, this kind of virtual DNA exists and is generated in phantom DNA effect as magnetic bodies of DNA, including of course the magnetic flux tubes connecting the nucleotides to the cell membrane or conjugate strand of DNA.
3. The crucial additional assumption would be that also the reversal of phantom DNA effect is possible and corresponds to the analog of DNA replication in which nucleotides attach to the virtual conjugate nucleotides of the virtual DNA strand or RNA strand in turn transformed

to DNA strand be reverse transcription. The hypothesis would have rather strong implications for the genetic engineering since homeopathic remedies of genetically engineered DNA sequences could be transferred to cell nuclei just by drinking them.

4. Phantom DNA sequences could form populations and - as far as their properties as a hardware of topological quantum computer are involved - evolve under selection pressures of the virtual world defined by the nuclear, cellular and extracellular water. A competition of components of TQC hardware developed by the higher level magnetic body to realize optimally TQC programs needed for survival would be in question. The simplest mutation of phantom DNA would replace the quark pairs at the ends the (wormhole-) magnetic flux tube with a new one and could occur in very short time scale. Also basic editing operations like cutting and pasting would be possible for these competing phantom DNA sequences. The winners in the competition would be transformed to actual DNA sequences by utilizing the reverse phantom DNA (or RNA -) effect and be inserted to genome. The genetic machinery performing cutting, gluing, and pasting of real DNA in a controlled manner exists. What is needed is the machinery monitoring who is the winner and making the decision to initiate the modification of the real DNA.
5. The transfer of the mutations to germ cells could be achieved by allowing the population of the virtual DNA sequences to infect the water inside germ cells. The genetic program inducing the modification of DNA by using the winner of the TQC hardware competition should run automatically.
6. One open question is whether the nuclear, cellular or perhaps also extracellular water should represent the physical environment and - if answer is affirmative - how it achieves this. As a matter fact, considerable fraction of water inside cells is in gel phase and it might be that the intercellular water, which naturally defines a symbolic representation of environment, is where the virtual evolution takes place. Internal chemical milieu certainly reflects in an abstract manner the physical environment and the ability of the water molecule clusters to mimic bio-molecules would make the representation of the chemical environment possible. Also sudden changes of external milieu would be rapidly coded to the changes in internal milieu which might help to achieve genetic re-organization. The craziest dream is water based simulation of both genes, proteins, and molecules representing external world running at dark space-time sheets.

Dark nuclear strings as analogs of DNA-, RNA- and amino-acid sequences and baryonic realization of genetic code?

The minimal option is that virtual DNA sequences have flux tube connections to the lipids of the cell membrane so that their quality as hardware of TQC can be tested but that there is no virtual variant of transcription and translation machinery. One can however ask whether also virtual amino-acids could be present and whether this could provide deeper insights to the genetic code.

1. Water molecule clusters are not the only candidates for the representatives of linear molecules. An alternative candidate for the virtual variants of linear bio-molecules are dark nuclei consisting of strings of scaled up dark variants of neutral baryons bound together by color bonds having the size scale of atom, which I have introduced in the model of cold fusion and plasma electrolysis both taking place in water environment [L3], [L3]. Colored flux tubes defining braidings would generalize this picture by allowing transversal color magnetic flux tube connections between these strings.
2. This seems to work! The states of dark nucleons formed from three quarks can be naturally grouped to multiplets in one-one correspondence with 64 DNAs, 64 RNAs, and 20 amino-acids and there is natural mapping of DNA and RNA type states to amino-acid type states such that the numbers of DNAs/RNAs mapped to given amino-acid are same as for the vertebrate genetic code.

The basic idea is simple. Since baryons consist of 3 quarks just as DNA codons consist of three nucleotides, one might ask whether codons could correspond to baryons obtained as open

strings with quarks connected by two color flux tubes. This representation would be based on entanglement rather than letter sequences. The question is therefore whether the dark baryons constructed as string of 3 quarks using color flux tubes could realize 64 codons and whether 20 amino-acids could be identified as equivalence classes of some equivalence relation between 64 fundamental codons in a natural manner.

The following model indeed reproduces the genetic code directly from a model of dark neutral baryons as strings of 3 quarks connected by color flux tubes.

1. Dark nuclear baryons are considered as a fundamental realization of DNA codons and constructed as open strings of 3 dark quarks connected by two colored flux tubes, which can be also charged. The baryonic strings cannot combine to form a strictly linear structure since strict rotational invariance would not allow the quark strings to have angular momentum with respect to the quantization axis defined by the nuclear string. The independent rotation of quark strings and breaking of rotational symmetry from $SO(3)$ to $SO(2)$ induced by the direction of the nuclear string is essential for the model.
 - (a) Baryonic strings could form a helical nuclear string (stability might require this) locally parallel to DNA, RNA, or amino-acid) helix with rotations acting either along the axis of the DNA or along the local axis of DNA along helix. The rotation of a flux tube portion around an axis parallel to the local axis along DNA helix requires that magnetic flux tube has a kink in this portion. An interesting question is whether this kink has correlate at the level of DNA too. Notice that color bonds appear in two scales corresponding to these two strings. The model of DNA as topological quantum computer [K3] allows a modification in which dark nuclear string of this kind is parallel to DNA and each codon has a flux tube connection to the lipid of cell membrane or possibly to some other bio-molecule.
 - (b) The analogs of DNA -, RNA -, and of amino-acid sequences could also correspond to sequences of dark baryons in which baryons would be 3-quark strings in the plane transversal to the dark nuclear string and expected to rotate by stringy boundary conditions. In this case all dark baryons would be free to rotate. Thus one would have nuclear string consisting of short baryonic strings not connected along their ends.
2. The new element as compared to the standard quark model is that between both dark quarks and dark baryons can be charged carrying charge $0, \pm 1$. This is assumed also in nuclear string model and there is empirical support for the existence of exotic nuclei containing charged color bonds between nuclei.
3. The net charge of the dark baryons in question is assumed to vanish to minimize Coulomb repulsion:

$$\sum_q Q_{em}(q) = - \sum_{flux\ tubes} Q_{em}(flux\ tube) . \quad (6.2.1)$$

This kind of selection is natural taking into account the breaking of isospin symmetry. In the recent case the breaking cannot however be as large as for ordinary baryons (implying large mass difference between Δ and nucleon states).

4. One can classify the states of the open 3-quark string by the total charges and spins associated with 3 quarks and to the two color bonds. Total em charges of quarks vary in the range $Z_B \in \{2, 1, 0, -1\}$ and total color bond charges in the range $Z_b \in \{2, 1, 0, -1, -2\}$. Only neutral states are allowed. Total quark spin projection varies in the range $J_B = 3/2, 1/2, -1/2, -3/2$ and the total flux tube spin projection in the range $J_b = 2, 1, -1, -2$. If one takes for a given total charge assumed to be vanishing one representative from each class (J_B, J_b) , one obtains $4 \times 5 = 20$ states which is the number of amino-acids. Thus genetic code might be realized at the level of baryons by mapping the neutral states with a given spin projection to single representative state with the same spin projection. The problem is to find whether one can identify the analogs of DNA, RNA and amino-acids as baryon like states.

1. States in the quark degrees of freedom

One must construct many-particle states both in quark and flux tube degrees of freedom. These states can be constructed as representations of rotation group $SU(2)$ and strong isospin group $SU(2)$ by using the standard tensor product rule $j_1 \times j_2 = j_1 + j_2 \oplus j_1 + j_2 - 1 \oplus \dots \oplus |j_1 - j_2|$ for the representation of $SU(2)$ and Fermi statistics and Bose-Einstein statistics are used to deduce correlations between total spin and total isospin (for instance, $J = I$ rule holds true in quark degrees of freedom). Charge neutrality is assumed and the breaking of rotational symmetry in the direction of nuclear string is assumed.

Consider first the states of dark baryons in quark degrees of freedom.

1. The tensor product $2 \otimes 2 \otimes 2$ is involved in both cases. Without any additional constraints this tensor product decomposes as $(3 \oplus 1) \otimes 2 = 4 \oplus 2 \oplus 2$: 8 states altogether. This is what one should have for DNA and RNA candidates. If one has only identical quarks uuu or ddd , Pauli exclusion rule allows only the 4-D spin $3/2$ representation corresponding to completely symmetric representation - just as in standard quark model. These 4 states correspond to a candidate for amino-acids. Thus RNA and DNA should correspond to states of type uud and ddu and amino-acids to states of type uuu or ddd . What this means physically will be considered later.
2. Due to spin-statistics constraint only the representations with $(J, I) = (3/2, 3/2)$ (Δ resonance) and the second $(J, I) = (1/2, 1/2)$ (proton and neutron) are realized as free baryons. Now of course a dark -possibly p-adically scaled up - variant of QCD is considered so that more general baryonic states are possible. By the way, the spin statistics problem which forced to introduce quark color strongly suggests that the construction of the codons as sequences of 3 nucleons - which one might also consider - is not a good idea.
3. Second nucleon like spin doublet - call it 2_{odd} - has wrong parity in the sense that it would require $L = 1$ ground state for two identical quarks (uu or dd pair). Dropping 2_{odd} and using only $4 \oplus 2$ for the rotation group would give degeneracies $(1, 2, 2, 1)$ and 6 states only. All the representations in $4 \oplus 2 \oplus 2_{odd}$ are needed to get 8 states with a given quark charge and one should transform the wrong parity doublet to positive parity doublet somehow. Since open string geometry breaks rotational symmetry to a subgroup $SO(2)$ of rotations acting along the direction of the string and since the boundary conditions on baryonic strings force their ends to rotate with light velocity, the attractive possibility is to add a baryonic stringy excitation with angular momentum projection $L_z = -1$ to the wrong parity doublet so that the parity comes out correctly. $L_z = -1$ orbital angular momentum for the relative motion of uu or dd quark pair in the open 3-quark string would be in question. The degeneracies for spin projection value $J_z = 3/2, \dots, -3/2$ are $(1, 2, 3, 2)$. Genetic code means spin projection mapping the states in $4 \oplus 2 \oplus 2_{odd}$ to 4.

2. States in the flux tube degrees of freedom

Consider next the states in flux tube degrees of freedom.

1. The situation is analogous to a construction of mesons from quarks and antiquarks and one obtains the analogs of π meson (pion) with spin 0 and ρ meson with spin 1 since spin statistics forces $J = I$ condition also now. States of a given charge for a flux tube correspond to the tensor product $2 \otimes 2 = 3 \oplus 1$ for the rotation group.
2. Without any further constraints the tensor product $3 \otimes 3 = 5 \oplus 3 \oplus 1$ for the flux tubes states gives $8+1$ states. By dropping the scalar state this gives 8 states required by DNA and RNA analogs. The degeneracies of the states for DNA/RNA type realization with a given spin projection for $5 \oplus 3$ are $(1, 2, 2, 2, 1)$. 8×8 states result altogether for both uud and udd for which color bonds have different charges. Also for ddd state with quark charge -1 one obtains $5 \oplus 3$ states giving 40 states altogether.
3. If the charges of the color bonds are identical as the are for uuu type states serving as candidates for the counterparts of amino-acids bosonic statistics allows only 5 states ($J = 2$

state). Hence 20 counterparts of amino-acids are obtained for uuu . Genetic code means the projection of the states of $5 \oplus 3$ to those of 5 with the same spin projection and same total charge.

3. Analogs of DNA, RNA, amino-acids, and of translation and transcription mechanisms

Consider next the identification of analogs of DNA, RNA and amino-acids and the baryonic realization of the genetic code, translation and transcription.

1. The analogs of DNA and RNA can be identified dark baryons with quark content uud , ddu with color bonds having different charges. There are 3 color bond pairs corresponding to charge pairs $(q_1, q_2) = (-1, 0), (-1, 1), (0, 1)$ (the order of charges does not matter). The condition that the total charge of dark baryon vanishes allows for uud only the bond pair $(-1, 0)$ and for udd only the pair $(-1, 1)$. These thus only single neutral dark baryon of type uud resp. udd : these would be the analogous of DNA and RNA codons. Amino-acids would correspond to uuu states with identical color bonds with charges $(-1, -1)$, $(0, 0)$, or $(1, 1)$. uuu with color bond charges $(-1, -1)$ is the only neutral state. Hence only the analogs of DNA, RNA, and amino-acids are obtained, which is rather remarkable result.
2. The basic transcription and translation machinery could be realized as processes in which the analog of DNA can replicate, and can be transcribed to the analog of mRNA in turn translated to the analogs of amino-acids. In terms of flux tube connections the realization of genetic code, transcription, and translation, would mean that only dark baryons with same total quark spin and same total color bond spin can be connected by flux tubes. Charges are of course identical since they vanish.
3. Genetic code maps of $(4 \oplus 2 \oplus 2) \otimes (5 \oplus 3)$ to the states of 4×5 . The most natural map takes the states with a given spin to a state with the same spin so that the code is unique. This would give the degeneracies $D(k)$ as products of numbers $D_B \in \{1, 2, 3, 2\}$ and $D_b \in \{1, 2, 2, 2, 1\}$: $D = D_B \times D_b$. Only the observed degeneracies $D = 1, 2, 3, 4, 6$ are predicted. The numbers $N(k)$ of amino-acids coded by D codons would be

$$[N(1), N(2), N(3), N(4), N(6)] = [2, 7, 2, 6, 3] .$$

The correct numbers for vertebrate nuclear code are $(N(1), N(2), N(3), N(4), N(6)) = (2, 9, 1, 5, 3)$. Some kind of symmetry breaking must take place and should relate to the emergence of stopping codons. If one codon in second 3-plet becomes stopping codon, the 3-plet becomes doublet. If 2 codons in 4-plet become stopping codons it also becomes doublet and one obtains the correct result $(2, 9, 1, 5, 3)!$

4. Stopping codons would most naturally correspond to the codons, which involve the $L_z = -1$ relative rotational excitation of uu or dd type quark pair. For the 3-plet the two candidates for the stopping codon state are $|1/2, -1/2\rangle \otimes \{|2, k\rangle\}$, $k = 2, -2$. The total spins are $J_z = 3/2$ and $J_z = -7/2$. The three candidates for the 4-plet from which two states are thrown out are $|1/2, -3/2\rangle \otimes \{|2, k\rangle, |1, k\rangle\}$, $k = 1, 0, -1$. The total spins are now $J_z = -1/2, -3/2, -5/2$. One guess is that the states with smallest value of J_z are dropped which would mean that $J_z = -7/2$ states in 3-plet and $J_z = -5/2$ states 4-plet become stopping codons.
5. One can ask why just vertebrate code? Why not vertebrate mitochondrial code, which has unbroken $A - G$ and $T - C$ symmetries with respect to the third nucleotide. And is it possible to understand the rarely occurring variants of the genetic code in this framework? One explanation is that the baryonic realization is the fundamental one and biochemical realization has gradually evolved from non-faithful realization to a faithful one as kind of emulation of dark nuclear physics. Also the role of tRNA in the realization of the code is crucial and could explain the fact that the code can be context sensitive for some codons.

4. Understanding the symmetries of the code

Quantum entanglement between quarks and color flux tubes would be essential for the baryonic realization of the genetic code whereas chemical realization could be said to be classical. Quantal aspect means that one cannot decompose to codon to letters anymore. This raises questions concerning the symmetries of the code.

1. What is the counterpart for the conjugation $YZZ \rightarrow X_c Y_c Z_c$ for the codons?
2. The conjugation of the second nucleotide Y having chemical interpretation in terms of hydrophobia-hydrophily dichotomy in biology. In DNA as TQC model it corresponds to matter-antimatter conjugation for quarks associated with flux tubes connecting DNA nucleotides to the lipids of the cell membrane. What is the interpretation in now?
3. The A-G, T-C symmetries with respect to the third nucleotide Z allow an interpretation as weak isospin symmetry in DNA as TQC model. Can one identify counterpart of this symmetry when the decomposition into individual nucleotides does not make sense?

Natural candidates for the building blocks of the analogs of these symmetries are the change of the sign of the spin direction for quarks and for flux tubes.

1. For quarks the spin projections are always non-vanishing so that the map has no fixed points. For flux tube spin the states of spin $S_z = 0$ are fixed points. The change of the sign of quark spin projection must therefore be present for both $XYZ \rightarrow X_c Y_c Z_c$ and $Y \rightarrow Y_c$ but also something else might be needed. Note that without the symmetry breaking $(1, 3, 3, 1) \rightarrow (1, 2, 3, 2)$ the code table would be symmetric in the permutation of 2 first and 2 last columns of the code table induced by both full conjugation and conjugation of Y .
2. The analogs of the approximate $A - G$ and $T - C$ symmetries cannot involve the change of spin direction in neither quark nor flux tube sector. These symmetries act inside the A-G and T-C sub-2-columns of the 4-columns defining the rows of the code table. Hence this symmetry must permute the states of same spin inside 5 and 3 for flux tubes and 4 and 2 for quarks but leave 2_{odd} invariant. This guarantees that for the two non-degenerate codons coding for only single amino-acid and one of the codons inside triplet the action is trivial. Hence the baryonic analog of the approximate $A - G$ and $T - C$ symmetry would be exact symmetry and be due to the basic definition of the genetic code as a mapping states of same flux tube spin and quark spin to single representative state. The existence of full 4-columns coding for the same amino-acid would be due to the fact that states with same quark spin inside $(2, 3, 2)$ code for the same amino-acid.
3. A detailed comparison of the code table with the code table in spin representation should allow to fix their correspondence uniquely apart from permutations of n-plets and thus also the representation of the conjugations. What is clear that Y conjugation must involve the change of quark spin direction whereas Z conjugation which maps typically 2-plets to each other must involve the permutation of states with same J_z for the flux tubes. It is not quite clear what X conjugation correspond to.

5. Some comments about the physics behind the code

Consider next some particle physicist's objections against this picture.

1. The realization of the code requires the dark scaled variants of spin $3/2$ baryons known as Δ resonance and the analogs (and only the analogs) of spin 1 mesons known as ρ mesons. The lifetime of these states is very short in ordinary hadron physics. Now one has a scaled up variant of hadron physics: possibly in both dark and p-adic senses with latter allowing arbitrarily small overall mass scales. Hence the lifetimes of states can be scaled up.
2. Both the absolute and relative mass differences between Δ and N resp. ρ and π due to color magnetic hyper-fine splitting are large in ordinary hadron physics and this makes the decays of Δ and ρ possible kinematically. This is due to color magnetic spin-spin splitting proportional to the color coupling strength $\alpha_s \sim .1$, which is large. In the recent case α_s could be considerably smaller - say of the same order of magnitude as fine structure constant

1/137 - so that the mass splittings could be so small as to make decays impossible. The masses of different states should not differ much: eV scales is suggestive.

The color magnetic spin interaction energy give rise to hyperfine splitting of quark in perturbative QCD is of form $E_c \propto \hbar g B / m$, where m is mass parameter which is of the order of baryon mass. Magnetic flux scales as \hbar by flux quantization and if flux tube thickness scales as \hbar^2 , one has $B \propto 1/\hbar$. Mass splittings would not depend on \hbar , which does not make sense. Mass splitting becomes small for large \hbar if the area of flux quantum scales as \hbar^{2+n} , $n > 0$ so that color magnetic hyper-fine splitting scales as $1/\hbar^n$ from flux conservation. The magnetic energy for a flux tube of length L scaling as \hbar and thickness $S \propto \hbar^{2+n}$ has order of magnitude $g^2 B^2 L S$ and does not depend on \hbar for $n = 1$. Maybe this could provide first principle explanation for the desired scaling.

The size scale of DNA would suggest that single DNA triplet corresponds to 3 Angstrom length scale. Suppose this corresponds to the size of dark nucleon. If this size scales as $\sqrt{\hbar}$ as p-adic mass calculations suggest, one obtains a rough estimate $\hbar/\hbar_0 = 2^{38}$. The proton- Δ mass difference due to hyper-fine splitting would be scaled down to about $2^{-38} \times 300 \text{ MeV} \sim 10^{-9} \text{ eV}$, which is completely negligible in the metabolic energy scale. 5 eV. If the size of dark nucleon scales as \hbar the mass difference is about 12 eV which corresponds to the energy scale for the ionization energy of hydrogen. Even this might be acceptable.

3. Dark hadrons could have lower mass scale than the ordinary ones if scaled up variants of quarks in p-adic sense are in question. Note that the model for cold fusion that inspired the idea about genetic code requires that dark nuclear strings have the same mass scale as ordinary baryons. In any case, the most general option inspired by the vision about hierarchy of conscious entities extended to a hierarchy of life forms is that several dark and p-adic scaled up variants of baryons realizing genetic code are possible.
4. The heaviest objection relates to the addition of $L_z = -1$ excitation to $S_z = |1/2, \pm 1/2\rangle_{\text{odd}}$ states which transforms the degeneracies of the quark spin states from $(1, 3, 3, 1)$ to $(1, 2, 3, 2)$. The only reasonable answer is that the breaking of the full rotation symmetry reduces $SO(3)$ to $SO(2)$. Also the fact that the states of massless particles are labeled by the representation of $SO(2)$ might be of some relevance. The deeper level explanation in TGD framework might be as follows. The generalized embedding space is constructed by gluing almost copies of the 8-D embedding space with different Planck constants together along a 4-D subspace like pages of book along a common back. The construction involves symmetry breaking in both rotational and color degrees of freedom to Cartan sub-group and the interpretation is as a geometric representation for the selection of the quantization axis. Quantum TGD is indeed meant to be a geometrization of the entire quantum physics as a physics of the classical spinor fields in the "world of classical worlds" so that also the choice of measurement axis must have a geometric description.

The conclusion is that genetic code can be understood as a map of stringy baryonic states induced by the projection of all states with same spin projection to a representative state with the same spin projection. Genetic code would be realized at the level of dark nuclear physics and biochemical representation would be only one particular higher level representation of the code. A hierarchy of dark baryon realizations corresponding to p-adic and dark matter hierarchies can be considered. Translation and transcription machinery would be realized by flux tubes connecting only states with same quark spin and flux tube spin. Charge neutrality is essential for having only the analogs of DNA, RNA and amino-acids and would guarantee the em stability of the states.

Crying and screaming cells and magnetic bodies expressing their emotions

By using nanotechnological methods James Gimzewski [J9], his student Andrew Pelling and collaborators discovered that the cell walls of bacterium *Saccharomyces cerevisiae* perform periodic motion with amplitude about 3 nm in the frequency range 8-1.6 kHz (one octave) [I105]. Or more concretely, bacteria produce sounds audible to humans with average frequency of 1 kHz in a range of one octave. The frequency has strong temperature dependence, which suggests a metabolic mechanism. From the temperature dependence one deduces the activation energy to

be 58 kJ/mol, which is consistent with the cell's metabolism involving molecular motors such as kinesin, dynein, and myosin. The magnitude of the forces observed (10 nN) suggests concerted nanomechanical activity is operative in the cell.

From less formal popular articles [I55] one can learn that it is difficult to avoid the impression that intelligent communication is in question. Dying cells produce a characteristic screaming sound. One can also distinguish between normal cells and cancer cells on basis of the sound they produce as well as between mammalian and bacterial cells.

What might be the explanation of these findings in TGD framework?

1. It is known that the region of frequencies audible to human ear is from about 20 Hz to 2×10^4 Hz. This is more or less same as the range of frequency range of sferics, the em noise in atmosphere [F6]. This suggests a strong coupling between electromagnetic oscillations and sound as also the fact that biological structures are piezo-electrets transforming em oscillations to sounds and vice versa.
2. The activation energy per mole corresponds to 6 eV per molecule which is at the upper range for the variation range the energy associated with the fundamental metabolic energy quantum identified as the change of zero point kinetic as proton is transferred from atomic space-time sheet to much larger space-time sheet or vice versa. That metabolic energy is needed to produce the sounds supports the view that the sounds are produced intentionally.
3. If one takes seriously the notion of magnetic body as intentional agent controlling biological body, one is led to ask which must sound a totally crazy question in reductionistic ears: could magnetic body express its emotions in terms of frequencies of cyclotron transitions transformed to sound via genetic expression using piezo electric mechanism? Could it be that the photons involved are dark photons with large value of Planck constant so that their energy is above thermal energy. Could one propose a materialistic scientist to consider anything more irritating than singing and crying magnetic bodies!
4. Suppose that the homeopathic mechanism is based on replication of pseudomolecules with same magnetic body as that of solvent molecules and that neutral dark nuclear strings realize analogs of DNA, RNA, and amino-acids and realizing genetic code exactly in its vertebrate nuclear form and appearing also in the TGD based model of cold fusion and biological transmutations. If so, then homeopathic mechanism (recognition of molecules) could involve also the transformation of cyclotron radiation to sound at the level of "biological bodies" of molecules.
5. If this picture makes sense then also our speech as a self expression of the magnetic body might involve genetic code mapping sequences of DNA codons to temporal patterns of cyclotron radiation in turn transformed to speech by above mechanism. This would require a realization of genetic code at level of dark matter: could it be that dark nuclear code could define universal quantum level realization of language? The findings of Peter Gariaev and others and structural resemblance of intronic portion of genome with language and their report that DNA sequences are coded to temporal patterns of the rotation angle of the polarization of laser light (in turn inducing genetic expression).

6.2.8 Direct Empirical Evidence For Dark DNA?!

Sciencedaily tells about extremely interesting finding related to DNA (<http://tinyurl.com/pbzqx36>). The finding is just what breakthrough discovery should be: it must be something impossible in the existing world view.

What has been found [L30] (<http://tinyurl.com/y9849jkz>) is that knock-out (removing parts of gene to prevent transcription to mRNA) and knock-down of gene (prevent protein translation) seem to have different consequences. Removing parts of gene need not have the expected effect at the level of proteins! Does this mean that somehow DNA as a whole can compensate the effects caused by knock-out but not those by knock-down? This explanation is natural in the standard conceptual framework and is proposed in the article.

Could this be explained by assuming that genome is a hologram as Gariaev *et al* (<http://tinyurl.com/ycosxzen>) [I82, I6] have first suggested? Also TGD leads to a vision about living

system as a conscious hologram [K21]. Small local changes of genes could be compensated. Somehow the entire genome would react like brain to a local brain damage: other regions of brain take the duties of the damaged region. Could the idea about DNA double strand as nano-brain having left and right strands instead of hemispheres help here. Does DNA indeed act as a macroscopic quantum unit? The problem is that transcription is local rather than holistic process. Something very simple should lurk behind the compensation mechanism.

Could transcription transform dark DNA to dark mRNA?

Also the TGD based notion of dark DNA comes in mind [K58, L3] (<http://tinyurl.com/ybp338x5>, <http://tinyurl.com/yag67j4p>). Dark DNA consists of dark proton sequences for which states of single DNA proton correspond to those of DNA, mRNA, aminoacids, and tRNA. Dark DNA is one of the speculative ideas of TGD inspired quantum biology getting support from Pollack's findings (<http://tinyurl.com/oyhstc2> [L25], [K88]). Ordinary biomolecules would only make their dark counterparts visible: dark biomolecules would serve as a template around which ordinary biomolecules such as DNA strands are formed in TGD Universe. All basic biomolecules of genetics would be pairs of ordinary biomolecule and its dark proton analog.

Although ordinary DNA is knocked out of ordinary gene, dark gene would still exist! If dark DNA actually serves as template for the transcription to mRNA, everything is still ok after knockout! Could it be that we do not understand even transcription correctly? Could it actually occur at the level of dark DNA and mRNA?! Dark mRNA would attach to dark DNA after which ordinary mRNA would attach to the dark mRNA. One step more!

Damaged DNA could still do its job! DNA transcription would have very little to do with bio-chemistry! If this view about DNA transcription is correct, it would suggest a totally new manner to fix DNA damages. These damages could be actually at the level of dark DNA, and the challenge of dark genetic engineering would be to modify dark DNA to achieve a proper functioning.

Could dark genetics help to understand the non-uniqueness of the genetic code?

Also translation could be based on pairing of dark mRNA and dark tRNA. This suggests a fresh perspective to some strange and even ugly looking features of the genetic code. Are DNA and mRNA always paired with their dark variants? Do also amino-acids and anticodons of tRNA pair in this manner with their dark variants? Could the pairings at dark matter level be universal and determined by the pairing of dark amino-acids with the anticodons of dark RNA? Could the anomalies of the code be reduced to the non-uniqueness of the pairing of dark and ordinary variants of basic bio-molecules (pairings RNA–dark RNA, amino-acid– dark amino-acid, and amino-acid–ordinary amino-acid in tRNA).

1. There are several variants of the genetic code differing slightly from each other: correspondence between DNA/mRNA codons and amino-acids is not always the same. Could dark-dark pairings be universal? Could the variations in dark anticodon - anticodon pairing and dark amino-acid-amino-acid pairing in tRNA molecules explain the variations of the genetic code?
2. For some variants of the genetic code a stop codon can code for amino-acid. The explanation at the level of tRNA seems to be the same as in standard framework. For the standard code the stop codons do not have tRNA representatives. If stop codon codes for amino-acids, the stop codon has tRNA representation. But how the mRNA knows that the stop codon is indeed stop codon if the tRNA associated with it is present in the same cell?

Could it be that stop codon property is determined already at the level of DNA and mRNA? If the dark variant of genuine stop codon is missing in DNA and therefore also in mRNA the translation stops if it is induced from that at the level of dark mRNA. Could also the splicing of mRNA be due to the splitting of dark DNA and dark mRNA? If so genes would be separated from intronic portions of DNA in that they would pair with dark DNA. Could it be that the intronic regions do not pair with their dark counterparts. They would be specialized to topological quantum computations in the TGD inspired proposal [K3].

Start codon (usually AUG coding met) serves as a Start codon defining the reading frame (there are 3 possible reading frames). Dark DNA would naturally begin from this codon.

3. Also two additional amino-acids Pyl and Sec appear in Nature. Gariaev *et al* have proposed that the genetic code is context dependent so that the meaning of DNA codon is not always the same. This non-universality could be reduced to the non-uniqueness of dark amino-acid–amino-acid pairing in tRNA if genetic code is universal.

Could dark genetics help to understand wobble base pairing?

Wobble base pairing (<http://tinyurl.com/y73se8vs>) is second not-so-well understood phenomenon. In the standard variant of the code there are 61 mRNAs translated to amino-acids. The number of tRNA anticodons (formed by the pairs of amino-acid and RNA molecules) should be also 61 in order to have 1-1 pairing between tRNA and mRNA. The number of ordinary tRNAs is however smaller than 61 in the sense that the number of RNAs associated with them is smaller than 45. tRNA anticodons must be able to pair with several mRNA codons coding for given amino-acid. This is possible since tRNA anticodons can be chosen to be representative for the mRNA codons coding a given amino-acid in such that all mRNA codons coding for the same amino-acid pair with at least one tRNA anticodon.

1. This looks somewhat confusing but is actually very simple: genetic code can be seen as a composite of two codes: first 64 DNAs/mRNAs to be coded to $N < 45$ anticodons in tRNA, and then these N anticodons are coded to 20 amino-acids. One must select N anticodon representatives for the mRNAs in the 20 sets of mRNA codons coding for a given amino-acid such that each amino-acid has at least one anticodon representative. A large number of choices is possible and the wobble hypothesis of Crick pose reduce the number of options.
2. The wobble hypothesis of Crick states that the nucleotide in the third codon position of RNA codon of tRNA has the needed non-unique base pairing: this is clear from the high symmetries of the third basis. There is exact U-C symmetry and approximate A-G symmetry with respect to the third basis of RNA codon (note that the conjugates of RNA codons are obtained by $A \leftrightarrow U$ and $C \leftrightarrow G$ permutations).
3. The first two basis in the codon pair in 1-1 manner to the second and third basis of anticodon. The third basis of anticodon corresponds to the third letter of mRNA codon. If it is A or C the correspondence is assumed to be 1-to-1: this gives 32 tRNAs. If the first basis of anticodon is G or U the 2 mRNA basis can pair with it: they would be naturally A for G and C for U by symmetry. One would select A from A-G doublet and C from U-C double. This would give 16 anticodons: 48 anticodons altogether, which is however larger than 45. Furthermore, this would not give quite the correct code since A-G symmetry is not exact.

Smaller number of tRNAs is however enough since the code has almost symmetry also with respect to A and C exchange not yet utilized. The trick is to replace in some cases the first basis of anticodon with Inosine I, which pairs with 3 mRNA basis. This replacement is possible only for those amino-acids for which the number of RNAs coding the amino-acid is 3 or larger (the amino-acids coded by 4 or 6 codons).

4. It can be shown at least 32 different tRNAs are needed to realize genetic code by using wobble base pairing. Full A-C and G-U symmetry for the third basis of codon would give $16+16=32$ codons. One can ask whether tRNA somehow realizes this full symmetry?

How dark variants of could help to understand wobble base pairing? Suppose for a moment that the visible genetics be a shadow of the dark one and fails to represent it completely. Suppose the pairing of ordinary and dark variants of tRNA anticodons *resp.* amino-acids and that translation proceeds at the level of dark mRNA, dark anticodons, and dark amino-acids, and is made visible by its bio-chemical shadow. Could this allow to gain insights about wobble base pairing? Could the peculiarities of tRNA serve for some other - essentially bio-chemical - purposes?

The basic idea would be simple: chemistry does not determine the pairing but it occurs at the level of the dark mRNA codons and dark tRNA anticodons. There would be no need to reduce wobble phenomenon to biochemistry and the only assumption needed would be that chemistry does not prevent the natural dark pairing producing standard genetic code apart from the modifications implied by non-standard dark amino-acid–amino-acid pairing explaining for different codes and the possibility that stop codon can in some situation pair with dark mRNA.

One can consider two options.

1. The number of dark RNAs is 64 and the pairings between dark mRNA and dark anticodons and dark anticodons and dark amino-acids are 1-to-1 and only the pairing between dark RNA codons and anticodons in tRNA is many-to-1.
2. The model of dark genetic code [K58] suggests that there are 40 dark proton states, which could serve as dark analogs of tRNA. This number is larger than 32 needed to realize the genetic code as a composite code. I have cautiously suggested that the proposed universal code could map dark mRNA states of the same total spin (there is breaking of rotational symmetry to that around the axis of dark proton sequences) to dark tRNA/dark amino-acid states with the same total spin projection. The geometric realization would in terms of color flux tubes connecting the dark protons of corresponding dark proton sequences. Also in ordinary nuclei the nucleons are proposed to be connected by color flux tubes so that they form nuclear strings [L3] and dark proton sequences would be essentially dark variants of nuclei.

One should understand the details of the dark mRNA–tRNA anticodon correspondence. One can also ask whether the dark genetic code and the code deduced from the icosahedral model for music harmony [K95] [L22] are mutually consistent. This model implies the decomposition of 60+4 DNA codons to 20+20+20+4 codons, where each “20” corresponds to one particular icosahedral Hamilton’s cycle with characteristic icosahedral symmetries. “4” can be assigned to tetrahedron regarded either disjoint from icosahedron or glued to it along one of its faces. This allows to understand both the standard code and the code with two stop codons in which exotic amino-acids Pyl and Sec appear. One should understand the compositeness $64 \rightarrow 40 \rightarrow 20$ of the dark genetic code and whether it relates to the icosatetrahedral realization of the code.

I have proposed [K63] (<http://tinyurl.com/ycm48w54>) that dark variants of transcription, translation, etc.. can occur and make possible kind of R&D laboratory so that organisms can test the consequences of variations of DNA. If ordinary translation and transcription are induced from their dark variants it would not be surprising and if dark biomolecules could also appear as unpaired variants, these processes could occur as purely dark variants. Organisms could indeed do experimentation in the virtual world model of biology and pairing with ordinary bio-molecules would make things real.

There is now evidence for this picture. It has been discovered [J66] (<http://tinyurl.com/oec3mff>) that brain cells have a mosaic like distribution of genomes (<http://tinyurl.com/odwajdq>). In standard framework this mosaic should be created by random mutations. The mechanism of mutation is reported to involve transcription rather than DNA replication. The mutation would take place for DNA when it is copied to RNA after opening of the DNA double strand. The mutations would have occurred during the period when neurons replicate and the mutation history can be read by studying the distributions of changes in the genome.

This brings in mind the finding that removing a part of gene does not affect transcription. In both cases it is dark DNA, which would serve as a template for transcription rather than ordinary DNA. This suggests that the dark DNA is not changed in these modifications and mRNA is determined by the dark DNA, which would serve as a template for transcription rather than ordinary DNA. If this were the case also for neurons, the mutations of neuronal genes should not affect the gene transcription at all, and there would be no negative (or positive) effects on brain function. This seems too conservative. The mutations should have some more active role.

One can consider also different interpretation. The mutations of DNA could be induced by the dark DNA. As dark DNA changes, ordinary DNA associated with it is forced to change too - sooner or later. Especially so when the genome is in a state in which mutations can take place easily. Neurons during to replication stage could have such quantum critical genomes.

Evolution would not be mere selection by a survival of random mutations by external environment in the time scale much longer than lifetime of individual - but a controlled process, which can occur in time scale shorter than lifetime and differently inside parts of say brain. This is what the idea TGD inspired biology suggests. The modified DNA could be dark DNA and serve as template for transcription and also induce transformation of ordinary DNA associated with it.

Whether this change can be transferred to the germ cells to be transferred to the offspring remains of course an open question. For instance, one can imagine that dark DNA strands (mag-

netic flux tubes) can penetrate germ cell membranes and replace the earlier dark DNA sections and induce change of ordinary DNA. Or is a more delicate mechanism involving dark photons in question. With inspiration coming from the findings reported by Peter Gariaev [I82] I have proposed a model of remote DNA replication suggesting that DNA can be replicated remotely if the needed nucleotides are present [K149]: the information about DNA could be transferred as dark photons, which can be transformed to ordinary photons identified as bio-photons. Could Lysenko have been at least partially right despite that he was a swindler basing his views on ideology?

In any case, TGD inspired biology allows to imagine a controlled evolution of DNA in analogy to that what occurs in R&D departments of modern technological organizations. The notion of dark DNA suggests that biological systems indeed have a "R&D department" in which new variants of DNA studied as "dark DNA" sequences realised as dark proton sequences - same about dark RNA, and amino-acids and even tRNA. The possibility to transcribe RNA from dark DNA would mean that the testing can be carried in real life situations.

There indeed exists evidence that traumatic - and thus highly emotional - memories may be passed down through generations in genome [J24] (<http://tinyurl.com/oja8v94>). Could the modifications of brain DNA represent long term memories as the above described experiment suggests? Could the memories be transferred to the germ cells using the mechanism sketched above?

6.3 Further Experimental Findings Related To Water Memory

In this section I discuss further experimental findings giving support for both TGD based view about water memory and TGD based vision about living cell.

6.3.1 Genes And Water Memory

After long time I had opportunity to read a beautiful experimental article about experimental biology. Yolene Thomas, who worked with Benveniste, kindly sent the article to me. The freely loadable article is *Electromagnetic Signals Are Produced by Aqueous Nanostructures Derived from Bacterial DNA Sequences* by Luc Montagnier, Jamal Aissa, Stephane Ferris, Jean-Luc Montagnier, and Claude Lavall'e published in the journal Interdiscip. Sci. Comput. Life Sci. (2009) [I102].

Basic findings at cell level

I try to list the essential points of the article. Apologies for biologists: I am not a specialist.

1. Certain pathogenic micro-organisms are objects of the study. The bacteria *Mycoplasma Pirum* and *E. Choli* belong to the targets of the study. The motivating observation was that some procedures aimed at sterilizing biological fluids can yield under some conditions the infectious micro-organism which was present before the filtration and absent immediately after it. For instance, one filtrates a culture of human lymphocytes infected by *M. Pirum*, which has infected human lymphocytes to make it sterile. The filters used have 100 nm and 20 nm porosities. *M. Pirum* has size of 300 nm so that apparently sterile fluids results. However if this fluid is incubated with a mycoplasma negative culture of human lymphocytes, mycoplasma re-appears within 2 or 3 weeks! This sounds mysterious. Same happens as 20 nm filtration is applied to a minor infective fraction of HIV, whose viral particles have size in the range 100-120 nm.
2. These findings motivated a study of the filtrates and it was discovered that they have a capacity to produce low frequency electromagnetic waves with frequencies in good approximation coming as the first three harmonics of kHz frequency, which by the way plays also a central role in neural synchrony. What sounds mysterious is that the effect appeared after appropriate dilutions with water: positive dilution fraction varied between 10^{-7} and 10^{-12} . The uninfected eukaryotic cells used as controls did not show the emission. These signals appeared for both *M. Pirum* and *E. Choli* but for *M. Pirum* a filtration using 20 nm filter

canceled the effect. Hence it seems that the nano-structures in question have size between 20 and 100 nm in this case.

A resonance phenomenon depending on excitation by the electromagnetic waves is suggested as an underlying mechanism. Stochastic resonance familiar to physicists suggests itself and also I have discussed it while developing ideas about quantum brain [K98]. The proposed explanation for the necessity of the dilution could be kind of self-inhibition. Maybe a gel like phase which does not emit radiation is present in sufficiently low dilution but is destroyed in high dilutions after which emission begins. Note that the gel phase would not be present in healthy tissue. Also a destructive interference of radiation emitted by several sources can be imagined.

3. Also a cross talk between dilutions was discovered. The experiment involved two tubes. Donor tube was at a low dilution of *E. Choli* and “silent” (and carrying gel like phase if the above conjecture is right). Receiver tube was in high dilution (dilution fraction 10^{-9}) and “loud”. Both tubes were placed in mu-metal box for 24 hours at room temperature. Both tubes were silent after this. After a further dilution made for the receiver tube it became loud again. This could be understood in terms of the formation of gel like phase in which the radiation does not take place. The effect disappeared when one interposed a sheath of mu-metal between the tubes. Emission of similar signals was observed for many other bacterial species, all pathogenic. The transfer occurred only between identical bacterial species which suggests that the signals and possibly also frequencies are characteristic for the species and possibly code for DNA sequences characterizing the species.
4. A further surprising finding was that the signal appeared in dilution which was always the same irrespective of what was the original dilution.

Experimentation at gene level

The next step in experimentation was performed at gene level.

1. The killing of bacteria did not cancel the emission in appropriate dilutions unless the genetic material was destroyed. It turned out that the genetic material extracted from the bacteria filtered and diluted with water produced also an emission for sufficiently high dilutions.
2. The filtration step was essential for the emission also now. The filtration for 100 nm did not retain DNA which was indeed present in the filtrate. That effect occurred suggests that filtration destroyed a gel like structure inhibiting the effect. When 20 nm filtration was used the effect disappeared which suggests that the size of the structure was in the range 20-100 nm.
3. After the treatment by DNase enzyme inducing splitting of DNA to pieces the emission was absent. The treatment of DNA solution by restriction enzyme acting on many sites of DNA did not suppress the emission suggesting that the emission is linked with rather short sequences or with rare sequences.
4. The fact that pathogenic bacteria produce the emission but not “good” bacteria suggests that effect is caused by some specific gene. It was found that single gene - adhesin responsible for the adhesion of mycoplasma to human cells- was responsible for the effect. When the cloned gene was attached to two plasmids and the *E. Choli* DNA was transformed with the either plasmid, the emission was produced.

Some consequences

The findings could have rather interesting consequences.

1. The refinement of the analysis could make possible diagnostics of various diseases and suggests bacterial origin of diseases like Alzheimer disease, Parkinson disease, Multiple Sclerosis and Rheumatoid Arthritis since the emission signal could serve as a signature of the gene causing the disease. The signal can be detected also from RNA viruses such as HIV, influenza virus A, and Hepatitis C virus.

2. Emission could also play key role in the mechanism of adhesion to human cells making possible the infection perhaps acting as a kind of password.

The results are rather impressive. Some strongly conditioned skeptic might have already stopped reading after encountering the word “dilution” and associating it with a word which no skeptic scientist in his right mind should not say aloud: “homeopathy” ! By reading carefully what I wrote above, it is easy to discover that the experimenters unashamedly manufactured a homeopathic remedy out of the filtrate! And the motivating finding was that although filtrate should not have contained the bacteria, they (according to authors), or at least the effects caused by them, appeared within weeks to it! This is of course impossible in the word of skeptic.

The next reaction of the skeptic is of course that this is fraud or the experimenters are miserable crackpots. Amusingly, one of the miserable crackpots is Nobelist Luc Montagnier, whose research group discovered AIDS virus.

How TGD could explain the findings?

Let us leave the raging skeptics for a moment and sketch possible explanations in TGD framework.

1. Skeptic would argue that the filtration allowed a small portion of infected cells to leak through the filter. Many-sheeted space-time suggests a science fictive variant of this explanation. During filtration part of the infected cells is “dropped” to large space-time sheets and diffused back to the original space-time sheets during the next week. This would explain why the micro-organisms were regenerated within few weeks. Same mechanism could work for ordinary molecules and explain homeopathy. This can be tested: look whether the molecules return back to the diluted solution in the case of a homeopathic remedy.
2. If no cells remain in the filtrate, something really miraculous looking events are required to make possible the regeneration of the effects serving as the presence of cells. This even in the case that DNA fragments remain in the filtrate.
 - (a) The minimum option is that the presence of these structures contained only the relevant information about the infecting bacteria and this information coded in terms of frequencies was enough to induce the signatures of the infection as a kind of molecular conditioning. Experimentalists can probably immediately answer whether this can be the case.
 - (b) The most radical option is that the infecting bacteria were actually regenerated as experimenters claim! The information about their DNA was in some form present and was transcribed to DNA and/or RNA, which in turn transformed to proteins. Maybe the small fragment of DNA (adhesin) and this information should have been enough to regenerate the DNA of the bacterium and bacterium itself. A test for this hypothesis is whether the mere nanoparticles left from the DNA preparation to the filtrate can induce the regeneration of infecting molecules.

The notion of magnetic body carrying dark matter quantum controlling living matter forms the basic element of TGD inspired model of quantum biology and suggests a more concrete model. The discovery of nanotubes connecting cells with distance up to 300μ [I63] provides experimental support for the notion.

1. If the matter at given layer of the onion-like structure formed by magnetic bodies has large \hbar , one can argue that the layer corresponds to a higher evolutionary level than ordinary matter with longer time scale of memory and planned action. Hence it would not be surprising if the magnetic bodies were able to replicate and use ordinary molecules as kind of sensory receptors and motor organs. Perhaps the replication of magnetic bodies preceded the replication at DNA level and genetic code is realized already at this more fundamental level somehow. Perhaps the replication of magnetic bodies induces the replication of DNA as I have suggested.

2. The magnetic body of DNA could make DNA a topological quantum computer [K3]. DNA itself would represent the hardware and magnetic bodies would carry the evolving quantum computer programs realized in terms of braidings of magnetic flux tubes. The natural communication and control tool would be cyclotron radiation besides Josephson radiation associated with cell membranes acting as Josephson junctions. Cyclotron frequencies are indeed the only natural frequencies that one can assign to molecules in kHz range. There would be an entire fractal hierarchy of analogs of EEG making possible the communication with and control by magnetic bodies.
3. The values of Planck constant would define a hierarchy of magnetic bodies which corresponds to evolutionary hierarchy and the emergence of a new level would mean jump in evolution. Gel like phases could serve as a correlate for the presence of the magnetic body. The phase transitions changing the value of Planck constant and scale up or down the size of the magnetic flux tubes. They are proposed to serve as a basic control mechanism making possible to understand the properties and the dynamics of the gel phases and how biomolecules can find each other in the thick molecular soup via a phase transition reducing the length of flux tubes connecting the biomolecules in question and thus forcing them to the vicinity of each other.

Consider now how this model could explain the findings.

1. Minimal option is that the flux tubes correspond to “larger space-time sheets” and the infected cells managed to flow into the filtrate along magnetic flux tubes from the filter. This kind of transfer of DNA might be made possible by the recently discovered nanotubes already mentioned.
2. Maybe the radiation resulted as dark photons invisible for ordinary instruments transformed to ordinary photons as the gel phase assignable with the dark matter at magnetic flux tube network associated with the infected cells and corresponding DNA was destroyed in the filtration.

This is not the only possible guess. A phase conjugate cyclotron radiation with a large value of Planck constant could also allow for the nanostructures in dilute solute to gain metabolic energy by sending negative energy quanta to a system able to receive them. Indeed the presence of ambient radiation was necessary for the emission. Maybe that for sufficiently dilute solute this mechanism allows to the nanostructures to get metabolic energy from the ambient radiation whereas for the gel phase the metabolic needs are not so demanding. In the similar manner bacteria form colonies when metabolically deprived. This sucking of energy might be also part of the mechanism of disease.

3. What could be the magnetic field inducing the kHz radiation as a synchrotron radiation?
 - (a) For instance, kHz frequency and its harmonics could correspond to the cyclotron frequencies of proton in magnetic field which field strength slightly above that for Earth’s magnetic field (750 Hz frequency corresponds to field strength of B_E , where $B_E = .5$ Gauss, the nominal strength of Earth’s magnetic field). A possible problem is that the thickness of the flux tubes would be about cell size for Earth’s magnetic field from flux quantization and even larger for dark matter with a large value of Planck constant. Of course, the flux tubes could make themselves thinner temporarily and leak through the pores.
 - (b) If the flux tube is assumed to have thickness of order 20-100 nm, the magnetic field for ordinary value of \hbar would be of order .1 Tesla from flux quantization and in the case of DNA the cyclotron frequencies would not depend much on the length of DNA fragment since it carries a constant charge density. Magnetic field of order .2 Tesla would give cyclotron frequency of order kHz from the fact that the field strength of .2 Gauss gives frequency of about .1 Hz. This corresponds to a magnetic field with flux tube thickness ~ 125 nm, which happens to be the upper limit for the porosity. Dark magnetic flux tubes with large \hbar are however thicker and the leakage might involve a temporary

phase transition to a phase with ordinary value of \hbar reducing the thickness of the flux tube. Perhaps some genes (adhesin) plus corresponding magnetic bodies representing DNA in terms of cyclotron frequencies depending slightly on precise weight of the DNA sequence and thus coding it correspond to the frequency of cyclotron radiation are the sought for nano-structures.

4. While developing a model for homeopathy based on dark matter I ended up with the idea that dark matter consisting of nuclear strings of neutrons and protons with a large value of \hbar and having thus a zoomed up size of nucleon could be involved. The really amazing finding was that nucleons as three quark systems allow to realize vertebrate code in terms of states formed from entangled quarks [L3], [L3] described also in this chapter! One cannot decompose codons to letters as in the case of the ordinary genetic code but codons are analogous to symbols representing entire words in Chinese. The counterparts of DNA, RNA, and amino-acids emerge and genetic code has a concrete meaning as a map between quantum states.

Without any exaggeration this connection between dark hadronic physics and biology has been one of the greatest surprises of my professional life. It suggests that dark matter in macroscopic quantum phase realizes genetic code at the level of nuclear physics and biology only provides one particular (or probably very many as I have proposed) representations of it. If one takes this seriously one can imagine that genetic information is represented by these dark nuclear strings of nanoscopic size and that there exists a mechanism translating the dark nuclei to ordinary DNA and RNA sequences and thus to biological matter. This would explain the claimed regeneration of the infected cells.

5. Genetic code at dark matter level would have far reaching implications. For instance, living matter - or rather, the magnetic bodies controlling it - could purposefully perform genetic engineering. This forces me to spit out another really dirty word, "Lamarckism" ! We have of course learned that mutations are random. The basic objection against Lamarckism is that there is no known mechanism which would transfer the mutations to germ cells. In the homeopathic Universe of TGD the mutations could be however performed first for the dark nucleon sequences. After this these sequences would diffuse to germ cells just like homeopathic remedies do, and after this are translated to DNA or RNA and attach to DNA.

The findings of both Montagnier and Gariaev suggests that also the representation of genetic code in terms of dark photons is involved. How genetic code could be represented in terms of frequencies? The TGD based model of music harmony [L22] [K95] (see <http://tinyurl.com/zg3aaj7>) relies on the idea that 12-note scale is representable as a closed non-self-intersecting curve (Hamilton's cycle) at icosahedron having 12 vertices. The harmony assignable to a given Hamilton's cycle is characterized in terms of 3-chords assignable to the 20 faces (triangles) of the icosahedron once the 12-note scale is represented as a particular Hamilton's cycle.

Remarkably, the number of amino-acids is also 20! One indeed ends up with a model in which $20+20+20=60$ DNA codons are represented by 3-chords for a triplet of harmonies defined by Hamilton's cycles predicting correctly the numbers of DNAs coding for a given amino-acid for vertebrate code. One must however assume that also tetrahedral harmony is present to get 64 DNA codons rather than only 60. TActually two variants of the code are predicted and altogether one obtains the standard 20 amino-acids plus two additional ones identified as Pyl and Sec known to be realized in living matter.

In music realization DNA codons can be represented as 3 dark photons or phonons with appropriate frequency ratios. This representation could explain the findings of Montagnier and Gariaev. There is also a connection with TGD inspired theory of consciousness. Music both expresses and induces emotions. The proposal is that the representation of DNA codons in terms of triplets of sounds or dark photons defines molecular level representation of emotions. There is large number of different harmonies and they could represent different moods.

6.3.2 Water Electric As Protocell

Ulla Matfolk sent to me some interesting material at the web page of Dr. Mae-Wan Ho which provides further insights into the model of cell. The articles are "Water electric" [D41] and "Making

Fuel from Water” [D39]. The articles summarize an experimental discovery which could be called Pollack-Zheng effect [D50, D45]. Both articles relate closely to what might be called the holy grail of artificial photosynthesis. The unreasonable effectiveness of photosynthesis in the sense that the waste of energy during the process is extremely small, makes artificial photosynthesis an excellent candidate for the final solution of energy problems as far energy sources and minimization of wastes are considered. In the following I comment only the first paper in detail from TGD viewpoint.

How photosynthesis manages to be so effective is one of the mysteries of biology. TGD based view about metabolic energy involves two ideas.

1. TGD predicts a hierarchy of metabolic energy quanta [K13, K62]. The basic quanta come as $E(k) = 2^k E_0$, where k is positive or negative integer and $E_0 \simeq .5$ eV holds true. For instance, 2 eV metabolic energy quantum corresponding to red light corresponds to $k = 3$. This is actually oversimplification since there is a cascade of quanta $E(k, n) = (1 - 2 < sup > - n < /sup >)E(k)$ converging to $E(k)$ for each p-adic length scale. These energies correspond to energies liberated when electron or proton drops to a larger space-time sheet at the limit when second space-time becomes very large and the particle starts from rest and remains to rest: this is second idealization as also the particle in a box geometry. The idea is that these universal metabolic energy quanta preceded the metabolism based on chemical storage of energy and that the primary step in photosynthesis is kicking of proton or electron to a smaller space-time sheet.
2. Second idea relies on the hierarchy of Planck constants.
 - (a) The rate of dissipation - that this the energy wasted per unit time - is inversely proportional to \hbar in the first naïve guess and means that macroscopically quantum coherent dark matter dissipates very little. Could photon kick charged dark particles to smaller space-time sheet where they dissipate very little? Or could photosynthesis capture ordinary or dark photons of sunlight to some layer of the onion like structure formed by the magnetic body of the organism, where it kicks particles to smaller space-time sheets. This light could correspond to bio-photons liberated as the biological body of the organism dies.
 - (b) Could this storage of photons have preceded chemical storage of energy in living matter? And could this energy reserve explain some rather mysterious findings about the ability of some people to survive without ordinary metabolic energy feed (usually saints and this kind of people telling that light is enough for them to survive. Also animals are capable to these metabolic miracles [I69] : see the article “Researchers Seek to Demystify the Metabolic Magic of Sled Dogs” in Science. Of course, the storage of energy to that of dark matter or dark photons confined to the net defined by magnetic flux tubes could be the eventual manner to avoid energy waste and associated entropy growth inducing environmental problems. Hierarchy of Planck constants would allow the storage in arbitrary long length scales for given energy of photon so that even a community of organisms could have collective metabolic energy resources: maybe synergy has something to do with this.

The first article summarizing the Pollack-Zheng effect gives quantitative support for this picture. I have formatted the text as comments to the summary represented in the article of Mae-Wan Ho [D41].

Exclusion zones

The article summarizes the sequence of events initiated by the discovery of Gerald Pollack and his student Jian-ming Zheng [D50, D45]. As a matter fact, the fascinating findings described in detail by Gerald Pollack in his book were absolutely crucial for the recent TGD based view about quantum biology in which dark matter plays key role.

1. Pollack and his student discovered that suspensions of colloids and dissolved substances are excluded from a region extending some hundreds of micrometres from the surfaces of

hydrophilic gels. An exclusion zone (EZ) of this magnitude conflicts the belief that interfacial water forming at liquid-solid, or liquid-air interfaces can be no more than a few layers of molecules thick. What's observed is a million layers or more! "Exclusion" means that the water suspension of micro-spheres moved away from the surface of gel with constant velocity and behaving like single structural unit.

Comment: The sizes of cells vary up to hundreds of micrometers and cells are by definition structures which are isolated from the environment. Maybe EZs represent protocells or their predecessors. Pollack and coauthors have indeed proposed that their finding might relate to the origin of life [D45]. That the surface was that of gel might be important. In TGD based model of living matter gels have magnetic bodies and their presence might relate to the formation of the thick water layer in non-standard phase.

2. Similar exclusion zones were found next to any hydrophilic surface including surfaces coated with a monolayer of hydrophilic molecules, and around ion exchange resin beads. Electric charge appears to be important, as EZ failed to form around charge-exhausted resin beads. Although EZ can form in pure water, it is enhanced and stabilized by low concentrations of buffer (2 to 10 mM at pH 7).

Comment: Hydrophily could correspond to the formation of magnetic flux tubes connecting the hydrophilic surface to water molecules as assumed in the model of protein folding and bio-catalysis [K7].

3. The EZ phase is very different from the bulk water. An unusually ordered crystalline phase where the molecules are less free to move is suggestive. The UV and visible absorption spectrum gave a single absorption peak at $\lambda \simeq 270$ nm in the UV region completely absent in the bulk phase. The infrared emission record showed that the EZ radiates very little compared with bulk water, as would be expected on account of the reduced mobility of water molecules. The magnetic resonance imaging mapping similarly gave a transverse relaxation time (T_2) of 25.4 ± 1 ms, which is shorter than the 27.1 ± 0.4 ms recorded for the bulk water phase, again indicative of restricted motion.

Comment: The reduced radiation might mean that part of photons are dark and bound inside magnetic flux tubes defining a structure responsible for the formation of gel like phases inside cell and perhaps also inside EZ. The interpretation as bio-photons is suggestive. This phase of water could be predecessor of the water in cell interior since in the crystalline phase long bio polymers like DNA and amino-acid sequences would be stable against hydration.

4. EZ had a different electrical potential from the bulk phase, by as much as 100–200 mV, depending on the hydrophilic surface. With a negatively charged surface such as polyacrylic acid or Nafion (widely used as a proton exchange membrane), the potential is negative compared with the bulk water away from the EZ. Simultaneously, the hydrogen ion (proton, H^+) concentration is high just outside the EZ, decreasing in a gradient away from it. This indicates that the formation of the EZ is accompanied by a separation of positive and negative electrical charges, which led to the build up of electrical potential between the EZ and the bulk water. In effect, the water has become an electrical battery, and can provide electricity through an external circuit.

Comment: Cell membrane is also a battery and the potential is around 50-80 mV to be compared with 100–200 mV, and the size scale of cell varies from 5 micrometer to hundreds of micrometers so that EZs could be involved with the formation of cell and cell membranes. The kicking of electrons or protons to smaller space-time sheet could be the mechanism inducing electric potential at a given space-time sheet. The formation of battery would mean that water could some day used to store very effectively the energy of solar radiation.

A connection with photosynthesis

Separating H^+ from e^- (electron) is the first step of photosynthesis in green plants which provides energy for most of the biosphere. In this case the energy comes from solar radiation. The separation of charges requires energy also in the case of EZ and the question is where this energy comes from in the case of EZ.

1. A clue came after having inadvertently left the experimental chamber with the EZ on the microscope overnight. Next morning, the EZ had shrunk considerably. But after turning on the microscope lamp, it began to immediately grow again, restoring itself within minutes to its former size. The energy for EZ formation comes from light, as in photosynthesis, but it can use the low energy part of the solar spectrum that photosynthesis cannot.

Comment: Could one consider the possibility that photosynthesis involves unknown step and this step is just the kicking of electrons or protons to a smaller space-time sheet. This step would also induce the separation of charges and the generation of electric potential.

2. Although the entire spectrum of visible light appeared effective in making the EZ grow, the most effective part is in the infrared region, peaking at $\lambda \simeq 3100$ nm. A 10 minute exposure at that wavelength expanded the width of an EZ 3.7 times, and after an hour of exposure, the expansion was more than 6 times. After the light was turned off, the EZ remained constant for about 30 minutes before beginning to shrink, reaching halfway to its baseline level in about 15 minutes.

Comment: $\lambda = 3100$ nm corresponds to .4 eV. The nominal value of the fundamental metabolic energy quantum is around $E_0 = .5$ eV and one has $E(k = 0, n = 3) = 0.4375$ eV for this value of E_0 . Perhaps the photons indeed kick electrons or protons to a smaller space-time sheet.

- (a) In the case of protons the smaller space-time sheet would correspond to atomic space-time sheets characterized by $p \simeq 2^{137}$: the larger one would correspond to $k = 141$.
 - (b) For electrons the size of the smaller space-time sheet would be by a factor $m_p/m_e = 940/.5 = 1880 \simeq 2^{11}$ larger and would correspond to $k = 137 + 11 = 148$. This is one half of the thickness of the lipid layer of cell membrane. The larger space-time sheet would correspond to cell membrane thickness $L(151) = 10$ nm and perhaps the dark space-time sheet serving as a template for the formation of the cell membrane! If $E = .4$ eV corresponds to electron, then proton would correspond to $E(0, 3) = .44$ eV giving for the metabolic energy quantum the value $E_0(p) = 0.5029$ eV in the case of proton and $E_0(e) = 0.4616$ eV in the case of electron.
3. When the UV and visible range was tested, a peak in the degree of EZ expansion was detected at $\lambda = 270$ nm in the UV region, corresponding to the characteristic absorption peak of EZ that was identified before. However, as the optical power used in the UV and visible region was 600 times that in the IR, the most profound effect was identified in the IR region, particularly at 3 100 nm.

Comment: $\lambda = 270$ nm corresponds to the energy 4.5926 eV. $E = 4$ eV is the nearest metabolic energy quantum. This energy does not correspond directly to any metabolic energy quantum assignable to .4 eV or .43 eV. One must be however cautious with conclusions since the model is very rough.

4. The mechanism of EZ formation is still unknown. But the two wavelengths that expand the EZ most effectively may offer some hint. The UV wavelength 270 nm is close to the 250 nm ($\simeq 5$ eV) required to ionize water under standard state conditions and taking into account the hydration of the resulting ions. The 3 100 nm peak, on the other hand is close to the OH stretch of the ring hexamer identified as the most abundant species in infrared predissociation spectroscopy of large water clusters, and also in neon matrices by infrared spectroscopy. These results suggest that photoexcitation of ring hexamers and photoionisation followed by ejection of protons play synergistic roles in the assembly of the EZ phase. Pollack and colleagues believe that the infrared radiation, though normally insufficient to break OH bonds, can nevertheless work via resonance induced dissociation of large hydrogen-bonded networks.

Comment: Ring hexamers bring in mind the crucial role of aromatic cycles in TGD inspired model of DNA as topological quantum computer which leads also to a model of $ADP \leftrightarrow ATP$ transition involving reconnection of magnetic flux tubes and having also information theoretic interpretation as a change of the topology of the braid structure defining topological quantum computer program [K3]. Magnetic flux tubes carrying dark electrons begin from these and can end up to other bio-molecules or water. Just a guess: could they end on ring hexamers?

Summary

The findings suggest additional details to the TGD based view about living matter.

1. The kicking of electrons or protons or both of them to a larger space-time sheet would be the first step in photosynthesis as I indeed suggested for years ago. The energy of 3100 nm photons indeed corresponds to that for the fundamental metabolic energy quantum. I have also proposed this process to be a fundamental step also in bio-catalysis: the temporary dropping of electron or proton of the catalyst molecule to a larger space-time sheet could provide the energy helping the reacting molecules to overcome the potential wall preventing the reaction from running. This metabolic coin could be returned to catalyst with high enough probability or the photons exchanged could be virtual.

In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant \hbar_{eff} so that cyclotron energy would be liberated. In the following only the “dropping” option is discussed.

2. The findings suggest also a mechanism for how solar radiation generates proto cells or their predecessors. The resulting phases of water have size extending to those for largest cells and the water could involve a gel like phase in which magnetic flux tubes containing dark matter could play a key role and eventually lead to quantum computer like behavior [K3]. The kicking of electrons (or protons) to smaller space-time sheet would induce ionization at given space-time sheet so that electric potential difference would result. The magnitude of the potential difference is of a correct order of magnitude. Cell membrane scale is present as a p-adic length scale for the space-time sheet of electrons before the kicking to the smaller space-time sheet and these space-time sheets could act as templates for the formation of cell membrane.
3. Interestingly, TGD based model of high T_c super conductivity predicts that both cell membrane length scale and size scale of cell are involved with the super-conductivity [K23]. Cell membrane acts as a Josephson junction in TGD based model of cell membrane, nerve pulse, and EEG.

6.3.3 A Model For Chiral Selection

Chiral selection of bio-molecules is one of the basic mysteries of biology and it is interesting to see whether the existing bits of data combined with vision about quantum TGD could help to build a coherent picture about the situation. Let us first try to identify the most important pieces of the puzzle.

1. Chiral selection requires parity breaking in the scale of biomolecules. Standard model predicts parity breaking interactions but the effects are extremely small above intermediate boson length scale which is by a factor 10^{-7} shorter than atomic length scale. The proposed solution of the problem is that dark variants of intermediate gauge bosons are in question so that the Compton lengths of intermediate gauge bosons are scaled up by a factor $r = \hbar/\hbar_0$. Below the dark Compton length weak gauge bosons would be effectively massless and above it possess ordinary masses. Large parity breaking effects induced by dark intermediate gauge bosons would be possible.
2. For instance, for $r = 2^{44}$ for which EEG photons have energies just above thermal threshold at room temperature, the effective p-adic length scale would correspond to $L(k)$, $k = 89 + 44 = 133$ of about .2 Angstrom. This scale in turn would scale up to $L(133 + 44 = 177)$. Secondary p-adic length scale assignable to $k = 89$ which is important in zero energy ontology would correspond to $k = 2 \times 89 = 178$ which corresponds to about $L(178) \simeq 100 \mu\text{m}$, the length scale assignable to large cells and the thickness of water layers in the experiment of Pollack.

3. Parity breaking interaction is associated with spin and the interaction energy of form $ks \cdot E_Z$, where s is the spin of particle and E_Z is Z^0 electric field. Classical induced gauge fields are very strongly correlated in TGD since they are expressible in terms of four CP_2 coordinates and their gradients. Hence classical electromagnetic field E is in the generic case accompanied by classical Z^0 field $E_Z = aE$. This means that if there is classical electromagnetic field and charge density at the dark space-time sheet, large parity breaking effect is possible at the level of spin. The induced Z^0 electric field could force the spins to become parallel and in this manner induce also magnetization.

The crucial finding about which I learned three years ago is that L glutamate is more stable than R glutamate in water and that heavy water does not induce this effect [?]. This suggests a connection with Pollack-Zheng effect [D50]. Heavy water nuclei have vanishing spin whereas hydrogen nuclei have spin 1/2 so that H_2 in water molecules can be in spin singlet or triplet states (para and orto configurations). Could the nuclear spin of water molecules somehow induce parity breaking and the magnetic interaction distinguishing between these molecules?

1. Suppose that bio-molecules in question have magnetic moment and water carries magnetic field, most naturally at dark magnetic flux tubes. The parity breaking interaction energy $-p \cdot E$ with dark electric field remains invariant under reflection and rotation of π changing the orientation of the mirror image of the molecule with respect to electric field. The interaction energy with magnetic field however changes its sign since magnetic moment is not affected by the reflection but changes direction under rotation. The angular momentum of the molecule responsible for the magnetic moment can of course change sign but since the transformation involves acts on angular momenta only, it is not a symmetry of entire system. Indeed, if there is interaction between angular momentum degrees of freedom and geometric degrees of freedom the magnetic interaction energy for the mirror image is different. Suppose that the breaking of reflection symmetry induced by the chirality of the molecule induces internal electric field E_{int} . The parity breaking interaction energy $ks \cdot E_{int}$ would indeed break the symmetry in the transformation changing the directions of angular momenta and spins.
2. It deserves to be emphasize that the parity breaking of the molecule itself would induce the symmetry breaking if molecule possesses dark magnetic body. One can actually imagine a cascade of parity breakings proceeding from shorter to longer length scales in this manner.
3. The mechanism creating electric field could be the charging of water, perhaps by the Pollack-Zheng mechanism and having in TGD framework an interpretation as a basic mechanism storing the energy of sunlight to metabolic energy (kicking of electrons and/or protons to a smaller space-time sheet so that oppositely charge space-time sheets emerge as a consequence). A direct connection with metabolism would be admittedly a highly satisfactory feature of the mechanism.
4. Parity breaking energy $ks \cdot E$ for say dark protons assignable to hydrogen nuclei of bio-molecules in the internal electric field of the molecule or dark protons of water molecules in the electric field induced by Pollack-Zheng effect [D50] does not change sign under the reflection of the molecule so that spin polarization independent of chirality could result form both water molecules in crystal like phase and for bio-molecules possessing dark protons (and dark hydrogen atoms). This could in turn serve as a seed for magnetization essential for the existence of dark magnetic flux tubes.

If water is replaced with heavy water there is no difference between L and R. What distinction H and D could explain this difference?

1. The basic difference between water and heavy water nuclei is that for water nucleus is just proton having spin 1/2 so that H_2 in water molecule can be in spin triplet and singlet states. Fractions of the two states are 3/4 and 1/4 in the absence of external magnetic field.
2. On the other hand, in atto-second time scale (corresponding length scale is 3 Angstroms) water is known to behave effectively as $H_{1.5}O$. A possible explanation is that 1/4: th of H nuclei/atoms are effectively dark having large Planck constant. The dark protons cannot

correspond to H_2 in spin singlet state since the interaction energy $ks \cdot E$ would be small in this case. Dark spin triplet states of H_2 could however induce parity breaking in water and make crystal like water phase both electret and magnet. If the spin $s_z = 1$ with negative interaction energy with E becomes dark then 1/4 of hydrogen atoms would be dark and $H_{1.5}O$ formula would hold true. For D_2O this mechanism would not work.

3. The model for homeopathy led to the idea that dark nuclei consisting of scale up variants of nucleons possibly having size of order atomic length scale could be crucial for understanding living matter. The states of nucleons correspond naturally to those DNA, RNA, and amino acids and vertebrate genetic code emerges naturally with DNA code word replaced with 3 quark state with entanglement between the quarks representing the information. Could it be that dark protons of water combine to form dark nuclei providing a fundamental representation of the genetic code and could the spin of protons induce electro-weak chiral symmetry breaking. Also now this mechanism fails for D_2O .

6.3.4 Burning Water And Photosynthesis

For a physicist liberated from the blind belief in reductionism, biology transforms to a single gigantic anomaly about which recent day physics cannot say much. During years I have constructed several models for these anomalies helping to develop a more detailed view about how the new physics predicted by quantum TGD could allow to understand biology and consciousness.

The basic problem is of course the absence of systematic experimentation so that it is possible to imagine many new physics scenarios. For this reason the article series of Mae-Wan Ho [D41, D39, D37, D40] in ISIS was a very pleasant surprise, and already now has helped considerably in the attempts to develop the ideas further.

The first article “Water electric” [D41] told about the formation of exclusion zones around hydrophilic surfaces, typically gels in the experiments considered [D50]. The zones were in potential of about 100 meV with respect to surroundings (same order of magnitude as membrane potential) and had thickness ranging to hundreds of micrometers (the size of a large cell): the standard physics would suggest only few molecular layers instead of millions. Sunlight induced the effect. This finding allowed to develop TGD based vision about how proto cells emerged and also the model for chiral selection in living matter by combining the finding with the anomalies of water about which I had learned earlier.

The article “Can water burn?” [D37] tells about the discovery of John Kanzius - a retired broadcast engineer and inventor. Kanzius found that water literally burns if subjected to a radio frequency radiation at frequency of 13.56 MHz [D2]. The mystery is of course how so low frequency can induce burning. The article “The body does burn water” [D40] notices that plant cells burn water routinely in photosynthesis and that also animal cells burn water but the purpose is now to generate hydrogen peroxide which kills bacteria (some readers might recall from childhood how hydrogen peroxide was used to sterilize wounds!). Hence the understanding of how water burns is very relevant for the understanding of photosynthesis and even workings of the immune system.

Living matter burns water routinely

Photosynthesis burns water by decomposing water to hydrogen and oxygen and liberating oxygen. Oxygen from CO_2 in atmosphere combines with the oxygen of H_2O to form O_2 molecules whereas H from H_2O combines with carbon to form hydrocarbons serving as energy sources for animals which in turn produce CO_2 . This process is fundamental for aerobic life. There is also a simpler variant of photosynthesis in which oxygen is not produced and applied by an-aerobic life forms. The article “Living with Oxygen” by Mae-Wan Ho gives a nice overall view about the role of oxygen [D38]. As a matter of fact, also animals burn water but they do this to produce hydrogen peroxide H_2O_2 which kills very effectively bacteria.

Burning of water has been studied as a potential solution for how to utilize the solar energy to produce hydrogen serving as a natural fuel [D39]. The reaction $O_2 + H_2 \rightarrow 2H_2O$ occurs spontaneously and liberates energy of about 1.23 eV. The reverse process $2H_2 \rightarrow H_2O_2 + H_2$ in the presence of sunlight means burning of water, and could provide the manner to store solar energy. The basic reaction $2H_2O + 4h\nu \leftrightarrow H_2O_2 + H_2$ stores the energy of four photons. What really

happens in this process is far from being completely understood. Quite generally, the mechanisms making possible extreme efficiency of bio-catalysis remain poorly understood. Here new physics might be involved. I have discussed models for photosynthesis and $ADP \leftrightarrow ATP$ process involved with the utilization of the biochemical energy already earlier [K62].

How water could burn in TGD Universe?

The new results could help to develop a more detailed model about what happens in photosynthesis. The simplest TGD inspired sketch for what might happen in the burning of water goes as follows.

1. Assume that 1/4 of water molecules are partially dark (in sense of nonstandard value of Planck constant) or at least at larger space-time sheets in atto-second scale [D35, D34, D46, D24]. This would explain the $H_{1.5}O$ formula explaining the results of neutron diffraction and electron scattering.
2. The question is what this exotic fraction of water precisely is. The models for water electret, exclusion zones and chiral selection lead to concrete ideas about this. Electrons assignable to the H atoms of (partially) dark H_2O reside at space-time sheet $k_e = 151$ (this p-adic length scale corresponds to 10 nm, the thickness of cell membrane). At least the hydrogen atom for this fraction of water molecules is exotic and findings from neutron and electron scattering suggest that both proton and electron are at non-standard space-time sheets but not necessarily at the same space-time sheet. The model for the burning requires that electron and proton are at different space-time sheets in the initial situation.
3. Suppose all four electrons are kicked to the space-time sheet of protons of the exotic hydrogen atoms labeled by k_p . This requires the energy $E_\gamma = (1 - 2^{-n})E_0(k_p)$ (the formula involves idealizations). At this space-time sheet protons and electrons are assumed to combine spontaneously to form two H_2 atoms. Oxygen atoms in turn are assumed to combine spontaneously to form O_2 .
4. For $k_f = 148$ and $n = 3$ minimum energy needed would be $4E_\gamma = 4 \times .4 = 1.6$ eV. For $k_p = 149$ (thickness of lipid layer) and $n = 2$ one would have $4E_\gamma = 4 \times .3462 = 1.385$ eV whereas $H_2O_2 + H_2 \rightarrow 2H_2O$ liberates energy 1.23 eV. Therefore the model in which electrons are at cell membrane space-time sheet and protons at the space-time sheet assignable to single lipid layer of cell membrane suggests itself. This would also mean that the basic length scales of cell are already present in the structure of water. Notice that there is no need to assume that Planck constant differs from its standard value.

There is no need to add, that the model is an unashamed oversimplification of the reality. It might however catch the core mechanism of photosynthesis.

Burning of salt water induced by RF radiation

Engineer John Kanzius has made a strange discovery [D2]: salt water in the test tube radiated by radio waves at harmonics of a frequency $f=13.56$ MHz burns. Temperatures about 1500 K, which correspond to 15 eV energy have been reported. One can irradiate also hand but nothing happens. The original discovery of Kanzius was the finding that radio waves could be used to cure cancer by destroying the cancer cells. The proposal is that this effect might provide new energy source by liberating chemical energy in an exceptionally effective manner. The power is about 200 W so that the power used could explain the effect if it is absorbed in resonance like manner by salt water.

Mae-Wan Ho's article "Can water Burn?" [D37] provides new information about burning salt water [D2], in particular reports that the experiments have been replicated. The water is irradiated using polarized radio frequency light at frequency 13.56 MHz. The energy of radio frequency quantum is $E_{rf} = .561 \times 10^{-7}$ eV and provides only a minor fraction $E_{rf}/E = .436 \times 10^{-7}$ of the needed energy which is $E = 1.23$ eV for single $2H_2O \rightarrow H_2O_2 + H_2$ event. The structure of water has been found to change, in particular something happens to O-H bonds. The Raman spectrum of the water has changed in the energy range [0.37, 0.43] eV. Recall that the range of metabolic energy quanta $E(k, n) = (1 - 2^{-n})E_0(k)$ varies for electron in the range [.35, .46] eV in the model

for the formation of exclusion zone induced by light. Therefore the photons assigned to changes in Raman spectrum might be associated with the transfer of electrons between space-time sheets.

The energies of photons involved are very small, multiples of 5.6×10^{-8} eV and their effect should be very small since it is difficult to imagine what resonant molecular transition could cause the effect. This leads to the question whether the radio wave beam could contain a considerable fraction of dark photons for which Planck constant is larger so that the energy of photons is much larger. The underlying mechanism would be phase transition of dark photons with large Planck constant to ordinary photons with shorter wavelength coupling resonantly to some molecular degrees of freedom and inducing the heating. Microwave oven of course comes in mind immediately.

As I made this proposal, I did not realize the connection with photosynthesis and actual burning of water. The recent experimental findings suggest that dark radio frequency photons transform to photons inducing splitting of water as in photosynthesis so that one should have $r = \hbar/\hbar_0 = E_{rf}/4E$. One could say that large number of radio wave photons combine to form a single bundle of photons forming a structure analogous to what mathematician calls covering space. In the burning event the dark photon would transform to ordinary photon with the same energy. This process would thus transform low energy photons to high energy protons with the ratio $r = \hbar/\hbar_0$.

Therefore the mechanism for the burning of water in the experiment of Kanzius could be a simple modification of the mechanism behind burning of water in photosynthesis.

1. Some fraction of dark radio frequency photons are dark or are transformed to dark photons in water and have energies around the energy needed to kick electrons to smaller space-time sheets .4 eV. After this they are transformed to ordinary photons and induce the above process. Their in-elastic scattering from molecules (that is Raman scattering) explains the observation of Raman scattered photons. For a fixed value of \hbar the process would occur in resonant manner since only few metabolic quanta are allowed.
2. How dark radio frequency photons could be present or could be produced in water? Cyclotron radiation assignable to say electrons in magnetic field comes in mind. If the cyclotron radiation is associated with electrons it requires a magnetic field of 4.8 Gauss the cyclotron frequency is 13.56 MHz. This is roughly ten times the nominal value $B_E = .5$ Gauss of the Earth's magnetic field and 24 times the value of dark magnetic field $B_d = .4B_E = .2$ Gauss needed to explain the effects of ELF em fields on vertebrate brain. Maybe dark matter at flux tubes of Earth's magnetic field with Planck constant equal to $\hbar/\hbar_0 = \frac{1}{4} \frac{E}{E_{rf}}$ transforms radio frequency photons to dark photons or induces resonantly the generation of cyclotron photons, which in turn leak out from magnetic flux tubes and form ordinary photons inducing the burning of water. $E_\gamma = .4$ eV would give $\hbar/\hbar_0 = 1.063 \times 2^{21}$ and $E_\gamma = .36$ eV would give $\hbar/\hbar_0 = .920 \times 2^{21}$.
3. Magnetic fields of magnitude .2 Gauss are in central role in TGD based model of living matter and there are excellent reasons to expect that this mechanism could be involved also with processes involved with living matter. There is indeed evidence for this. The experiments of Gariaev demonstrated that the irradiation of DNA with 2 eV laser photons (which correspond to one particular metabolic energy quantum) induced generation of radio wave photons having unexpected effects on living matter (enhanced metabolic activity) [185], and that even a realization of genetic code in terms of the time variation of polarization direction could be involved. TGD based model [K21, K132] identifies radio-wave photons as dark photons with same energy as possessed by incoming visible photons so that a transformation of ordinary photons to dark photons would have been in question. The model assumed hierarchy of values of magnetic fields in accordance with the idea about onion like structure of the magnetic body.

There are several questions to be answered.

1. Is there some trivial explanation for why salt must be present or is new physics involved also here. What comes in mind are Cooper pairs dark Na^+ ions (or their exotic counterparts which are bosons) carrying Josephson currents through the cell membrane in the model of the cell membrane as a Josephson junction which is almost vacuum extremal of Kähler action. In the experimental arrangement leading to the generation of exclusion zones the pH of water

was important control factor, and it might be that the presence of salt has an analogous role to that of protons.

2. Does this effect occur also for solutions of other molecules and other solutes than water? This can be tested since the rotational spectra are readily calculable from data which can be found at net.
3. Are the radio wave photons dark or does water - which is very special kind of liquid - induce the transformation of ordinary radio wave photons to dark photons by fusing $r = \hbar/\hbar_0$ radio wave massless extremals (MEs) to single ME. Does this transformation occur for all frequencies? This kind of transformation might play a key role in transforming ordinary EEG photons to dark photons and partially explain the special role of water in living systems.
4. Why the radiation does not induce spontaneous combustion of living matter which contains salt. And why cancer cells seem to burn: is salt concentration higher inside them? As a matter fact, there are reports about [D6]. One might hope that there is a mechanism inhibiting this since otherwise military would be soon developing new horror weapons unless it is doing this already now. Is it that most of salt is ionized to Na^+ and Cl^- ions so that spontaneous combustion can be avoided? And how this relates to the sensation of spontaneous burning [D5] - a very painful sensation that some part of body is burning?
5. Is the energy heating solely due to rotational excitations? It might be that also a "dropping" of ions to larger space-time sheets is induced by the process and liberates zero point kinetic energy. The dropping of proton from $k=137$ ($k=139$) atomic space-time sheet liberates about .5 eV (0.125 eV). The measured temperature corresponds to the energy .15 eV. This dropping is an essential element in the earlier of remote metabolism and provides universal metabolic energy quanta. It is also involved with TGD based models of "free energy" phenomena. No perpetuum mobile is predicted since there must be a mechanism driving the dropped ions back to the original space-time sheets.

In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant \hbar_{eff} so that cyclotron energy would be liberated.

6. The electrolysis of water and also cavitation produces what is known as Brown's gas which should consist of water vapour and there might be a connection to the burning of salt water. The properties of Brown's gas [H11] however do not support this interpretation: for instance, Brown's gas has temperature of about 130 C but is able to melt metals so that some un-known mechanism liberating energy must be involved explaining also the claims about over-unity energy production in water splitting using electrolysis. TGD inspired model for Brown's gas [K63] suggests that activated water and Brown's gas correspond to same phase involving polymer sequences formed from exotic water molecules for which one hydrogen nucleus is dark and defining the analogs of basic biopolymers. The bond binding protons to a polymer like sequence would serve as the counterpart of covalent bond.

One also ends up with a more detailed TGD inspired view about basic mechanism of metabolism in living matter predicting a tight correlation between p-adic length scale hypothesis and hierarchy of Planck constants. The model differs in some aspects from the rough models considered hitherto assuming that metabolic energy is liberated as zero point kinetic energy when particle drops to a larger space-time sheet or as cyclotron energy when cyclotron quantum number decreases. Now a phase transition increasing the p-adic length scale of the space-time surface would liberate either kinetic energy of cyclotron energy. Quantum numbers would not change: rather, the scale appearing as a parameter in the expression of kinetic or cyclotron energy would change adiabatically and in this manner guarantee coherence. Also a phase transition in which the changes of scale due to a reduction of Planck

constant and increase of the p-adic length scale compensate each other liberate metabolic energy.

Recall that one of the empirical motivations for the hierarchy of Planck constants came from the observed quantum like effects of ELF em fields at EEG frequencies on vertebrate brain and also from the correlation of EEG with brain function and contents of consciousness difficult to understand since the energies of EEG photons are ridiculously small and should be masked by thermal noise.

Free radicals, expanding Earth, water memory, and Cambrian revolution

The title is intentionally chosen to involve notions which one would expect to have absolutely nothing in common. The purpose is to show that this expectation might be wrong. Consider first the free radical theory [I20]. The theory states that free radical produced in mitochondria are responsible for the ageing since they are highly reactive and cause damage for the DNA. One can however wonder what is the mechanism causing the generation of the free radicals.

A TGD based justification for the free radical theory came as unexpected application of the quantum model for how metabolic batteries are loaded in many-sheeted space-time. The kicking of electrons to smaller space-time sheet loads metabolic batteries in TGD Universe. The dropping of electrons back liberates metabolic energy. These processes occur all the time in $\text{ADP} \leftrightarrow \text{ATP}$ “Karma’s” cycle. The quantitative model for the burning of water producing hydrogen peroxide and hydrogen (this process could provide a mechanism of storing solar energy by a mechanism analogous to photosynthesis) as already discussed.

Burning water, photo synthesis, and water memory

The burning of water, photons synthesis and water memory are closely interrelated phenomena in TGD Universe. Recall first what was observed in the experiments carried out by the group led by Luc Montagnier.

1. What was done was filtration of human cells infected by bacteria in sterilization purpose to eliminate the infected cells. Human cells were added to the filtrate. Rather magically, the infection returned to the filtrate within few weeks. Something having size of order of nanoscale leaked through. It was also found that when the filtrate was diluted by water to produce an analog of homeopathic remedy, it produced at multiples of kHz if the dilution factor was in the range $10^{-7} - 10^{-12}$.
2. The second discovery was that if you have two bottles containing a solute of nanostructures such that for the first one dilution factor is small and for the second in the critical range so that it radiates at kHz frequencies. What was found that in the final situation neither radiates but only if the dilutions correspond to the same bacterial species! I proposed two interpretations. The first one was that the nanoscale systems in the highly diluted system are starving and gain metabolic energy by sending negative energy photons to the low dilution system and this makes them possible to replicate and achieve higher dilution after which the process stops.
3. One of the most fascinating possibilities suggested by the discovery is that the nanoscale structures identified as certain gene of the bacteria plus possibly something else (the magnetic body of gene in TGD context) might have been able to regenerate the bacteria themselves! This would require a non-chemical representation of genetic code and its translation to DNA or RNA. For about year ago I indeed discovered a realization of genetic code in terms of dark nuclei with states of nucleons representing the code words [L3], [L3].

These findings allow a more detailed interpretation of the findings of the experiments of the group of Luc Montagnier.

1. The mysterious burning of water induced by radio waves in GHz range and interpreted in terms of a decomposition of water molecules to hydrogen peroxide and hydrogen: $2H_2 \rightarrow H_2O_2 + H_2$ is closely related to the splitting of water to hydrogen and oxygen occurs also

in photosynthesis. The interpretation was that radio waves are resonantly transformed to dark photons with same frequency but with very large value of Planck constant and hence of energy followed by a transformation to ordinary IR photons with much higher frequency but same energy around 4 eV. The finding that Raman scattering (non-elastic scattering of photons on molecules) around this energy occurs in the burning water supports this view. The natural guess is that also in the recent case something similar occurs.

2. This kind of frequency scaling is one of the basic mechanisms of water memory as I learned for the first time from the lecture of Cyril Smith in CASYS conference many years ago. One of the basic findings was that there is an unknown mechanism transforming low frequencies to high ones and vice versa. The low frequencies are scaled up by a factor which has a preferred value $r \simeq 2 \times 10^{11}$ interpreted in TGD framework as the ratio of the dark matter Planck constant to the ordinary one. I christened this correlation as a scaling law of homeopathy.
3. It is interesting to apply the law to kHz frequency. In this case the law would give frequency $f = 2 \times 10^{14} > \text{Hz}$. The corresponding energy is .826 eV, which is essentially twice the energy quantum associated with burning water and thus has interpretation as a p-adically scaled up frequency (by one octave). Interestingly, Mae-Wan Ho states in [D38] that *“to use water as electron-donor, and hence to produce oxygen, requires the creation of the chlorophyll-a in cyanobacteria and green plants that can be boosted to a higher electrochemical potential of 0.82 V”*. Hence .83 eV is very near to a metabolically interesting energy.
4. This finding supports the view that kHz radiation produced by nano-structures corresponds to dark phase conjugate photons with energy equal to a metabolic energy quantum. The interpretation would be that the unidentified nanoscale systems in the highly diluted system are starving and get metabolic energy by sending negative energy quanta in the hope that there are metabolic energy reservoirs around able to absorb them. If bio-photons are Bose Einstein condensates of dark cyclotron photons at the flux tubes of magnetic body acting like population reversed lasers, they could serve as metabolic energy reservoir as suggested in on basis of the discovery described by Mae-Wan Ho in [D41].
5. A continual fight for metabolic resources is raging everywhere in Nature, presumably also at the monocellular level. It would not be surprising if harmful bacteria would try to steal the metabolic energy of other organisms stored (say) as bio-photons by sending phase conjugate light to the bio-photon resources of multicellular organisms. Nor it would be surprising if living organisms would have developed ways to prevent this. The fine tuning of the metabolic frequencies so that only the members of the same species can share the energy could guarantee this. Also password like protocols might have developed and either or both of them might be involved.

In the two-bottle experiments the nanoscale systems in the highly diluted system would gain metabolic energy by sending negative energy photons received by the low dilution system. The gain of metabolic energy would make possible for the nanosystems to replicate and achieve higher dilution after which the process would stop as was indeed observed. That this took place only for the bacteria of same species supports the interpretation that frequency tuning or password mechanism was involved. This metabolic mechanism (quantum credit card as I have called it) could be a completely general mechanism energy sharing mechanism for cells of the same multicellular organism and perhaps even same species in TGD Universe.

6.4 DNA Waves And Water

The article “DNA waves and water” by L. Montagnier, J. Aissa, E. Del Giudice, C. Lavalley, A. Tedeschi, and G. Vitiello [I103] has created quite a furor even before its publication. The article was preceded by article [I102], whose results led to my own proposal about the existence of new kind of representation of DNA in water [L9] and the recent article indeed suggests the existence of a new kind nano-scale representation of DNA besides electromagnetic representation of the code, which was also suggested for years ago by the group of Peter Gariaev [I82] and also in TGD framework [K56]. New Scientist reacted by an article “Scorn over claim of teleported DNA” [I41],

whose title is completely misleading (nothing new in popular science journalism dominated by sensationalism): authors make no claim about quantum teleportation.

Already “DNA waves and water” is enough to induce a deep growl from the throat of a hard-nosed skeptic, and the words “homeopathy” and “water memory” are the signals, which transform even civilized skeptic to a raging blood hound. Water memory at gene level is indeed what the article is about. What makes the situation so problematic is that Montagnier is HIV Nobelist so that it is not so easy to dismiss the work as has been done routinely for all work related to water memory since the days of Benveniste and before.

The story began when Benveniste found evidence for water memory [I74, I75]. Water solution of biomolecules was diluted so that there was no trace about the molecules. What Benveniste and collaborators claimed was that the treated water is however somehow able to represent the biologically relevant properties of molecules so that its action on some biomolecules can be the same as that of the original molecules. This could obviously explain the claimed effects of homeopathy.

Benveniste got a label of fraudster in a scientific investigation led by the magician James Randi (true, this is what the standards of skeptic science sadly often are!). The work of Benveniste has been however continued behind the scenes and it has been for a long time to possible to reproduce the effects of biologically active molecules by using only the low frequency electromagnetic spectrum of these molecules which suggest that biological signalling relies on low frequency electromagnetic radiation [I75]. Skeptics have simply dismissed all this research.

That genes have electromagnetic representation have been also claimed by Peter Gariaev and his collaborators for long time ago in terms of the notion of wave DNA [I82] (references contain also other articles of Gariaev and collaborators). I have proposed TGD inspired models for wave DNA related effects [K132, K1]. The latter article has been written in collaboration with Peter Gariaev. Also bio-photons [I107] and the effects of ELF electromagnetic fields on vertebrate brain [J48] relate very closely to the story in TGD framework. Quite generally, the findings provide additional key data allowing to develop the vision about the central role of electromagnetism related macroscopic effects in living matter.

Also Huping Hu and Maoxin Wu [J81] have reported highly brain effects involving water and electromagnetic fields. Applying magnetic pulses to the brain when an anesthetic was placed in between caused the subject person to feel the effect of anesthetic. Also drinking water exposed to magnetic pulses, laser light or microwave radiation when an anesthetic was placed in between caused brain effects. The proposed interpretation was in terms of quantum entanglement. The explanation based on the mimicry of the anesthetic molecules by water does not exclude the presence of quantum entanglement.

In the following I will develop a more detailed model for the findings reported in [I102] using the new findings of Montagnier’s team [I103]. The findings provide information allowing to develop much more detailed view about water memory and representations of genetic code in terms of water and related ideas about the role of dark matter (understood as a hierarchy of phases with large value of Planck constant) in biology.

6.4.1 The Basic Findings Of Montagnier’s Group

The claim of Montagnier’s team is that the radiation generated by DNA affects water in such a way that it behaves as if it contained the actual DNA. A brief summary of experiment of Montagnier and collaborators is in order.

1. Two test tubes containing 100 bases long DNA fragments were studied. Both tubes were subjected to 7 Hz electromagnetic radiation. Earth’s magnetic field was eliminated to prevent its possible interference (the cyclotron frequencies of Earth’s magnetic field are in EEG range and one of the family secrets of biology and neuroscience since seventies is that cyclotron frequencies in magnetic fields have biological effects on vertebrate brain). The frequencies around 7 Hz correspond to cyclotron frequencies of some biologically important ions in the endogenous magnetic field of 2 Tesla explaining the findings. This field is 2/5 of the nominal value of the Earth’s magnetic field.
2. What makes the situation so irritating for skeptics who have been laughing for decades for homeopathy and water memory is that the repeated dilution process used for the homeopathic

remedies was applied to DNA in the recent case. The dilution containing no detectable amounts DNA (dilution factor was 10^{-12}) was placed in second test tube whereas the first test tube contained 100 bases long DNA in the original concentration.

3. After 16 to 18 hours both tubes were subjected to polymerase chain reaction (PCR), which builds DNA from its basic building bricks using DNA polymerase enzyme. What is so irritating that DNA was generated also in the test tube containing the highly diluted water. Water seems to be able to cheat the polymerase by mimicking the presence of the actual DNA serving in the usual situation as a template for building copies of DNA. One could also speak about the analog quantum teleportation.

In TGD inspired quantum biology the representations of genes in terms of temporal patterns of em radiation are in central role. TGD leads to a concrete model for water memory in terms of the magnetic body of biomolecule whose cyclotron frequency pattern codes for the biological effects of the molecule. Water memory means that water can build magnetic bodies mimicking those of biomolecules or perhaps steal them in the process of dilution which involves the shaking of the solution.

TGD suggest also another representation of the genetic code in terms of dark nucleons [L3], [L3], which could be highly relevant for the realization of water memory in terms of a dark portion of water for which there exist empirical evidence [K45]. This dark portion would also explain the numerous anomalies of water. It became as a total surprise that the states of dark nucleons correspond in natural manner to DNA, RNA, tRNA, and amino-acids. DNA would define only one particular representation of the genetic code, which in the primary form would be realized at elementary particle level and that there could exist many representations of DNA. Also the model for DNA as topological quantum computer [K3] proposes a non-standard representation of the code.

The existence of a multitude of representations of the code would not be too surprising when one realizes that the information processing performed by computers involves endless variety of different representations of various codes. The problem is about attitudes: the dogma that biology is nothing but chemistry is what is being challenged and we love dogmas because they liberate us from the burden of using our own brains.

6.4.2 Questions

Montagnier's work gives support for water memory in terms of representations of some molecules in terms of water molecules or some nano-structures present in water treated in the same manner as the homeopathic remedies are made. What is really amazing is that the representations seem also to realize genetic code. The experimental arrangement stimulates several questions which I try to answer in the framework of TGD inspired model of biology.

1. The presence of 7 Hz magnetically induced oscillation seems to be necessary for the presence of the effect. What is the role of this radiation whose frequency is not far from the lowest Schumann resonance frequency with nominal value of 7.83 Hz. Recall that this frequency is in the lowest approximation determined by the radius of Earth of alone. The wave length of 7 Hz photons is slightly larger than the circumference of Earth. Could it be that a temporal pattern associated with a single period of 7 Hz oscillation could code for DNA codons. The energies involved are of course ridiculously small as compared to the thermal energy at room temperature and quantal effects are excluded in standard quantum theory.
2. How water could represent some biologically relevant aspects of molecules? For what kind of molecules this representation does exist? What are the roles of mechanical agitation and dilution in the generation of water memory? Does the 7 Hz frequency near the lowest Schumann resonance frequency relate to this somehow?
3. How water and electromagnetic radiation could represent genetic code?

6.4.3 TGD Inspired Answers To The Questions

In the following TGD inspired answers to the questions posed in the introduction are discussed. The answers are of course very tentative and involve a lot of speculative new and non-tested physics predicted by TGD.

Some key ideas of TGD inspired quantum biology

TGD helps to imagine possible answers to these questions. The identification of dark matter as a hierarchy of phases with large Planck constant [K47, K45] and the notion of magnetic body [L9] - both deriving naturally from basic quantum TGD- are the key notions.

1. The basic vision is that magnetic body communicates with biological body and controls it by using a generalized variant of EEG consisting of fractal hierarchy of dark photons corresponding to a hierarchy of values of Planck constant [K44] with large Planck constant implying that even ELF photons can have thermal energies above thermal energy. This is the essential element in the model for the effects of ELF frequencies on vertebrate brain. The transformation of dark photon to a bunch of ELF photons or single high energy photon would be basic mechanisms transforming dark photons to ordinary ones. Biophotons would be dark photons transformed to single dark photon. EEG would represent outcome consisting of a bunch of ELF photons.
2. TGD suggests that dark DNA, RNA, ... and even dark amino-acids could have a key role in biological evolution providing kind of virtual world realization of biomolecules. This would make possible a controlled evolution analogous to the research and development carried out in industry. This is in conflict with the vision of standard biology according to which the planning of travel phone would be a process in which one throws some random collection of electronic components to a hat and looks whether a travel phone emerges from the hat after sufficiently long waiting period.

Biological R&D would require that transcription and translation process have dark counterparts. Also the transcription of dark DNA to ordinary DNA and vice versa and even more general processes should be possible. If the water containing ordinary DNA contains its dark variant able by its darkness to leak through the filters used in the experimental situation studied by Montagnier and collaborators, the dark DNA could be able to cheat the polymerase protein so that it interprets dark DNA as a genuine DNA template and starts to generate ordinary DNA. If the magnetic flux tubes coding for DNA are all that is relevant for this, this mechanism would not depend whether the ends of flux tubes contain real or dark DNA.

3. The dark magnetic flux tubes connecting bio-molecules make it possible for them to recognize and find each other in the dense soup of biomolecules. The reduction of Planck constant for the flux tube brings the bio-molecules near to each other so that catalytic reaction becomes possible. The reconnection process for flux tubes is also in an essential role and involved with ADP-ATP process and would provide elegant realization of codes.
4. In this framework evolutionary leaps can be seen as a quantum leap in which a new level of dark matter hierarchy with Planck constant larger than those of already existing levels emerges. Another basic implication is the existence of coherent gene expressions in various length scales leading to the notion of hypergenome and collective gene expression.

Representations for the genetic code in TGD

TGD suggest several non-standard representations of the genetic code.

1. Temporal patterns of electromagnetic radiation with some carrier frequency is one possibility. Gariaev's work suggests that temporal patterns of polarization directions of radiation could code for DNA sequences with each nucleotide corresponding to a definite change of polarization direction [K132]. This would mean a hierarchy of realizations of the code corresponding to different frequency scales with period of radiation defining the duration of the code word.

2. The TGD inspired model for DNA as topological quantum computer [K3] suggests a realization of codons in terms of u, and d quarks and their antiquarks at the ends of magnetic flux tubes connecting DNA nucleotides to lipids of nuclear or cellular membranes. TGD indeed predicts the possibility of several fractally scaled up copies of hadron physics with different mass scales and also dark variants of ordinary hadron physics with the Compton lengths of quarks scaled up while keeping mass scales the same. Entire fractal hierarchy of representations corresponding to carrier frequencies of dark photons could be realized.
3. One of the most amazing predictions of TGD comes from the model of dark nucleons [L3], [L3]. The states of dark nucleons are in 1-1 correspondence with DNA, RNA, tRNA, and amino-acids and vertebrate genetic code is realized naturally as dark nuclear strings analogous to ordinary nuclei which are also nuclear strings in TGD based model of nuclei. The representation could be based on triplets of magnetic flux tubes with quarks at ends correlating with the genetic code words defined by the states of dark nuclei just like the representation of DNA in DNA as TQC model. A natural guess would be that the size scale of dark nucleon is same as the size scale of single DNA triplet.

Montagnier's and Gariaev's findings suggest that genetic code is also represented in terms of frequencies. How this could be achieved? The TGD based model of music harmony [L22] [K95] (see <http://tinyurl.com/zg3aaj7>) relies on the idea that 12-note scale is representable as a closed non-self-intersecting curve (Hamilton's cycle) at icosahedron having 12 vertices. The harmony assignable to a given Hamilton's cycle is characterized in terms of 3-chords assignable to the 20 faces (triangles) of the icosahedron once the 12-note scale is represented as a particular Hamilton's cycle.

Remarkably, the number of amino-acids is also 20! One indeed ends up with a model in which $20+20+20=60$ DNA codons are represented by 3-chords for a triplet of harmonies defined by Hamilton's cycles predicting correctly the numbers of DNAs coding for a given amino-acid for vertebrate code. One must however assume that also tetrahedral harmony is present to get 64 DNA codons rather than only 60. TActually two variants of the code are predicted and altogether one obtains the standard 20 amino-acids plus two additional ones identified as Pyl and Sec known to be realized in living matter.

In music realization DNA codons can be represented as 3 dark photons or phonons with appropriate frequency ratios. This representation could explain the findings of Montagnier and Gariaev. There is also a connection with TGD inspired theory of consciousness. Music both expresses and induces emotions. The proposal is that the representation of DNA codons in terms of triplets of sounds or dark photons defines molecular level representation of emotions. There is large number of different harmonies and they could represent different moods.

What is the role of 7 Hz radiation?

7 Hz is near the frequency of the lowest Schumann resonance representing collective oscillation of the Earth's magnetic field and one can wonder about its role in the experiment of Montagnier and collaborators.

1. 7 Hz need not provide a representation for genetic code although it could do so. A possible role is as the provider of bio-rhythm and as a possible source of energy in the case that dark photons with energy above thermal energy are in question. TGD inspired theory of consciousness predicts what I call self hierarchy and one can speak about gene expression at the level of organism and even population. Schumann resonance would naturally couple with living matter and couple the magnetic bodies of living systems to the magnetic body of Earth- magnetic Mother Gaia one might say. Flux tubes within flux tubes would be simplest representation for the coupling making possible frequency modulation and also amplitude modulation. Frequency modulation is especially interesting and the song of whales provides a possible concrete example of underlying frequency modulation. The model for hologram generating properties of DNA suggests that the dark photons assignable to 7 Hz radiation pump energy to build up hologrammic representations of DNA.
2. Cyclotron resonances for ions in the Earth's magnetic field are in 1-100 Hz range and it has been known from seventies that electromagnetic fields in this frequency range have effects

of vertebrate brain. These effects look very quantal and correspond to cyclotron frequencies which is $2/5$ of the nominal value of the Earth's magnetic field. Also the authors of the article suggest that cyclotron resonances of ions are involved and in TGD inspired model for living body in terms of magnetic bodies cyclotron resonances are in a key role. Cyclotron frequencies could provide a coupling of biologically important ions to Schumann resonance if the flux tubes involved can vary their thickness so that the strength of magnetic field varies by flux conservation.

3. VLF frequencies above kHz seem to take this role in water memory. The wave lengths and corresponding layers of magnetic bodies are still enormous as compared to that of DNA.

How water could represent molecules?

The TGD inspired model for how water could represent at least some aspects of at least some molecules is based on earlier ideas plus some ideas inspired by the findings of Montagnier's group and by the role of ordered water and hydrogen bonds in the self-organization of biomolecules.

1. The basic idea is that the magnetic body of the molecules represents biologically relevant aspects of molecule in the sense that the cyclotron radiations generated by the magnetic body is responsible for biological control and also receives signals from part of organism in some length and time scales. The mechanical agitation of water involves in the process generating water memories implies that the magnetic bodies of some molecules just drop to water. This is enough for the mimicry of the biomolecules by water.
2. Water interacts strongly with polar (hydrophilic) molecules so that the polarity of the molecules in question is expected to be very relevant for the process. Polar molecules are covered by a hydrogen bonded layer of ordered water molecules analogs to ice covering. This molecular ice freezes various biomolecules to standard configuration and the feed of energy freezes the ice cover so that processes like protein folding and formation of their aggregates which is central element in the reaction of living matter to external perturbations becomes possible. The natural idea is that the polar molecules having hydrogen bonds with water layer dictate to high degree the structure of the magnetic body.
3. The mechanical agitation of water could feed the energy needed to induce the splitting of the hydrogen bonds of a polar molecule so that the ice coating to which the magnetic body of the molecule would drop out. The process would be similar to the reaction of biomolecule to external influence. This magnetic body would represent the molecule in terms of cyclotron frequencies and behave as a real molecule as far as the effects caused by cyclotron frequencies are considered. Basically a symbolic representation of the biomolecule would be in question.

This mechanism is obviously very general and the prediction is that water remembers the presence of molecules with polar regions and do not distinguish between molecules with different non-polar regions. These non-polar regions are hydrophobic and tend to be shielded from water. Protein folding is one example of this shielding.

How the magnetic bodies could represent genetic code?

The intriguing finding that about $1/4$ of hydrogen atoms of water behave effectively like dark matter in atto-second time scale was one of the first findings motivating the development of ideas about dark matter as large \hbar phases and is also of crucial importance for the model of water memory. The TGD based explanation is that dark hydrogen atoms correspond to dark protons with Compton size of order atom size at least. The varying fraction of this phase would explain the large number of anomalies related to the thermodynamics of water.

The proposal is that the splitting of hydrogen bond transforms the hydrogen or at least the proton of hydrogen to a dark nucleon. The states of dark nucleons would correspond to multiplets assignable to DNA, RNA, tRNA code words, and amino acids. If the state of dark nucleon corresponds to quarks assignable to the ends of the three magnetic flux tubes, one has a representation of the genetic code in terms of dark nuclear string consisting of protons glued to form dark nuclear string (TGD indeed leads to a model of nuclei as nucleon sequences connected by color magnetic bonds [K34]).

How transcription and translation type processes could be realized for dark DNA and how dark DNA and DNA could transform to each other?

Reconnection of magnetic flux tubes allows to imagine a very simple model for how DNA is coded to dark DNA and vice versa. As a matter of fact, the process applies to very general class of processes defining a pairing of biomolecules. All that is needed is that the quark pair at the ends of the flux tube to some degree dictates which molecules can form. One can actually imagine a generalization of the genetic code applying to much more general molecules than molecules involved with the genetic code if this mechanism involves dark nucleons at the ends of the magnetic flux tubes involves.

1. Assume that the nucleotides of dark DNA and conjugate molecules are connected by flux tubes having quark and antiquark at their ends that u, d and their antiquarks correspond in one-one manner to DNA nucleotides so that coding results. Suppose that similar coding takes place for dark DNA in the sense that dark DNA code word is connected by three flux tubes to its conjugate for corresponding dark amino-acid. Assume that both dark and ordinary DNA nucleotides can be connected to their conjugates by relatively long flux tubes (large \hbar) and that they can be also accompanied by short-circuited flux loops. Assume again that genetic code mapping codons to quarks is realized. Similar short circuited closed flux loops could be possible for amino-acids and RNA.
2. Assume that a reconnection for long flux tube connecting nucleotides and their conjugates and for nucleotide flux loop is possible if corresponding quarks are same so that the assignment realizes genetic code. For instance, a reconnection in the middle of flux tubes connecting dark DNA and its conjugate would generate an ordinary DNA sequence. If this sequence binds to DNA strand and if the reverse of the reconnection process occurs after that, dark DNA sequence becomes coded ordinary DNA sequence. Obviously much more general processes of this kind are possible and are relatively independent of what is at the ends of the flux tubes so that genetic code would permeate whole biology and determined selection rules of reaction involving all kinds of polar molecules.

What is the role of dilution and agitation?

I have already discussed these questions. The following discussion involves new ideas inspired by the findings of Montagnier's group.

The role of dilutions in the generation of water memories looks like a mystery and provides strongest weapon for a simple-minded skeptic and one can make only guesses in this respect. The situation does not distinguish between DNA and other molecules which water is able to represent. All these molecules could correspond to dark molecules resulting when the hydrogen bonds connecting polar molecule to its water coating split if above ideas are on a right track. Consider now the questions.

1. Is the dilution necessary in order that the magnetic flux tubes of the molecular magnetic expected to have size of order 100 nm in the solution do not overlap? This would mean that the density of dark DNA in the experiments of Montagnier would be rather low in the experimental situation, maybe something like 1 DNA sequence per volume of cell nucleus. Can so low density explain the effects of polymerase in the experiment of Montagnier's team? Could the critical dilution be the dilution above which the 7 Hz radiation is able to serve as a metabolic resource?
2. Could it be that the density of dark molecules is actually much higher than the dilution would suggest? This would require replication of dark molecules, which is indeed quite conceivable if dark molecules define a life form preceding ordinary DNA. The mechanical agitation could provide the metabolic energy for the dark molecules. Dark molecules could also be part of time in lethargic state and wake up only when energy is fed and replicate just as biomolecules are ice-covered and wake up only when external perturbation feeds energy and induces self-organization. But why would be critical dilution required? Why the density of ordinary molecules must be so small? This is difficult to understand.

3. Is it the number of dilutions and agitations which matters rather than the density of the ordinary molecules in the final situation? Could the sequence of dilutions induce an evolutionary process analogous to a sequence of environmental catastrophes posing evolutionary pressures (population density for dark molecules is reduced by a factor of ten) and leading to rapid evolution of dark DNA variant able to replicate and survive? Could each mechanical agitation induce quantum phase transitions increasing the value of Planck constant for the flux tubes inducing evolutionary leaps and increasing the size scale of the corresponding magnetic body? Could the associated feed of metabolic energy also induce a replication of the dark molecules so that one would have a population with a density much higher than that of the ordinary molecules in the final situation? Whether the number of agitation-dilution processes matters instead of final density of molecules could be tested by using different initial values for the density.
4. Cyclotron radiation of dark photons from the magnetic body of dark DNA transforming to ordinary VLF photons serves as a signature for its presence. In the abstract of [I101] Montagnier group reports following.

Electromagnetic signals of low frequency have been shown to be durably produced in aqueous dilutions of the Human Immunodeficiency Virus DNA. In vivo, HIV DNA signals are detected only in patients previously treated by antiretroviral therapy and having no detectable viral RNA copies in their blood. We suggest that the treatment of AIDS patients pushes the virus towards a new mode of replication implying only DNA, thus forming a reservoir insensitive to retroviral inhibitors. Implications for new approaches aimed at eradicating HIV infection are discussed.

“New mode of replication” would correspond in TGD framework to replication of magnetic bodies of RNA or DNA representing genes as dark nucleon sequences and would allow HIV RNA or RNA to survive despite the treatment.

The idea about rapid micro-evolution taking place in human time scale for the magnetic bodies is as radical as it is fascinating but is in principle testable. I have considered alternative explanations but they are not so simple as this one. I do not of course believe that attitudes in biological sciences would be mature for testing this kind of ideas. Big changes in the world view are painful and take place slowly and existing theoretical hegemony is the worst obstacle in the progress.

6.5 About Physical Representations of Genetic Code in Terms of Dark Nuclear Strings

The view about evolution as a random process suggests that genetic code is pure accident. My own view is that something so fundamental as life cannot be based on pure randomness. TGD has led to several proposals for genetic code, its emergence, and various realizations based on purely mathematical considerations or inspired by physical ideas. One can argue that genetic code is realized in several ways just like bits can be represented in very many ways. Two especially interesting proposals have emerged. The first one is based on geometric model of music harmony involving icosahedral and tetrahedral geometries. Second model has two variants based on dark nuclear strings: the original version maps codons to dark nucleons, the more recent version maps codons to dark 3-nucleon states. Both models predict correctly the numbers of DNA codons coding for a given amino-acid but the model based on dark 3-nucleon triplets is favoured by some recent findings suggesting a pairing between DNA nucleotides and dark nucleons. Also the counterparts of RNA, tRNA, and amino-acids are predicted. In the sequel the updated nuclear string variant is summarized and also its connection with the model of harmony is discussed.

6.5.1 Background

The view about evolution as a random process suggests that genetic code is pure accident. My own view is that something so fundamental as life cannot be based on pure randomness. TGD has led to several proposals for genetic code, its emergence, and various realizations based on purely mathematical considerations or inspired by physical ideas (see chapters of [K55] and [L3, K58]). One can argue that genetic code is realized in several ways just like bits can be represented in very many ways.

Two especially interesting proposals have emerged. The first one is based on geometric model of music harmony [L22] involving icosahedral and tetrahedral geometries. Second one having two variants is based on dark nuclear strings. Both models predict correctly the numbers of DNA codons coding for a given amino-acid. In the sequel the nuclear string variant and also its connection with the model of harmony is discussed in detail.

It is good to start with an overall view about physical realization of genetic code that I have discussed during last twenty years.

Genetic code and Combinatorial Hierarchy

The first proposal [K56] was purely mathematics inspired and in terms of so called Combinatorial Hierarchy consisting of certain Mersenne primes $M_k = 2^k - 1$ via the formula $M(n+1) = M_{M(n)}$ having interpretation in terms of abstraction. The list beginning from $M(1) = 2$ is 2, $M_2 = 3$, $M_3 = 7$, $M_7 = 127$, $M_{127} = 2^{127} - 1$: it is not known whether subsequent integers are Mersenne primes. The idea is that the $2^k - 1$ points define almost full Boolean algebra spanned by k bits- one visualization is as a polygon. The algebra defined $k - 1$ bits is maximal full Boolean sub-algebra having interpretation as maximal number of mutually independent statements, which can hold true simultaneously. For M_7 ($k = 3$) one would have 2 bits and 4 codons. For M_7 one would have $k = 7$ and 6 bits and genetic code. For M_{127} one would have 126 bits and one would have “memetic” code realizable in terms of sequences of 21 DNA codons.

Geometric theory of harmony and genetic code

The idea that the 12-note scale could allow mapping to a closed path going through all vertices of icosahedron having 12 vertices and not intersecting itself is attractive. Also the idea that the triangles defining the faces of the icosahedron could have interpretation as 3-chords defining the notion of harmony for a given chord deserves study. The paths in question are known as Hamiltonian cycles and there are 1024 of them [A2]. There paths can be classified topologically by the numbers of triangles containing 0, 1, or 2 edges belonging to the cycle representing the scale. Each topology corresponds to particular notion of harmony and there are several topological equivalence classes.

In the article [L27] I introduced the notion of Hamiltonian cycle as a mathematical model for musical harmony and also proposed a connection with biology: motivations came from two observations. The number of icosahedral vertices is 12 and corresponds to the number of notes in 12-note system and the number of triangular faces of icosahedron is 20, the number of amino-acids. This led to a group theoretical model of genetic code and replacement of icosahedron with tetra-icosahedron to explain also the 21st and 22nd amino-acid and solve the problem of simplest model due to the fact that the required Hamilton’s cycle does not exist. The outcome was the notion of bioharmony.

All icosahedral Hamilton cycles with symmetries (Z_6, Z_4, Z_2^{rot} and Z_2^{refl}) turned out to define harmonies consistent with the genetic code. In particular, it turned out that the symmetries of the Hamiltonian cycles allow to predict the basic numbers of the genetic code and its extension to include also 21st and 22nd amino-acids Pyl and Sec: there are actually two alternative codes - maybe DNA and its conjugate are talking different dialects! One also ends up with a proposal for what harmony is leading to non-trivial predictions both at DNA and amino-acid level.

The conjecture is that DNA codons correspond to 3-chords perhaps realized in terms of dark photons or even ordinary sound. There are 256 different bio-harmonies and these harmonies would give additional degrees of freedom not reducing to biochemistry. Music expresses and creates emotions and a natural conjecture is that these bio-harmonies are correlates of emotions/moods at bio-molecular level serving as building bricks of more complex moods. Representations of codons

as chords with frequencies realized as those of dark photons and also sound is what suggests itself naturally. This together with adelic physics involving hierarchy of algebraic extensions of rationals would explain the mysterious looking connection between rational numbers defined by ratios of frequencies with emotions.

Letter-wise representations of genetic code in terms of single particle states

The model for DNA-cell membrane system as topological quantum computer with lipids and DNA nucleotide or codons connected by flux tubes led to a proposal for the correspondence of letters of genetic code with particle states.

1. The original proposal was that the 4 letters A,T,C,G correspond to dark u and d quark and their antiparticles \bar{u} and \bar{d} . Quarks and their antiparticles would reside at the ends of the flux tube. Spin would not matter in this model. The obvious criticism is that introducing dark antiquarks is too far fetched.
2. One can also consider a variant for which one has u and d quarks and spin matters.
3. TGD based model of bio-superconductivity assumes that flux tubes appear as pairs with members of Cooper pair at parallel flux tubes [K93, K94]. This suggests that electron pairs at in spin 1 and spin 0 states could realize the code. The spin of the electrons would matter and one would obtain 4 states - two qubits in correspondence with A,T,C,G.

Also the model of dark nuclear strings allows to imagine letter-wise representations of the genetic code. The model for cold fusion based on the findings of Prof. Holmlid and his group [C1, L45] leads to the idea that Pollack's EZs [L25] are accompanied by dark nuclear strings consisting of dark protons connected by color flux tubes analogous to mesons [L29, L45]. Color bonds would have quark and antiquark at their ends [L3]. This leads to non-trivial predictions and nuclear anomalies giving support for the notion of nuclear string have emerged, the latest anomaly is so called X boson with mass of 17 MeV [L47, C4] having identification as p-adically scaled analog of pion.

Dark protons could also decay to neutrons by dark weak decays rapidly since dark weak bosons are effectively massless below dark Compton length. Furthermore, proton plus negatively charged color bond could behave like neutron as far as chemistry is considered. The X boson anomaly of nuclear physics [L47] suggests that the flux tubes in the ground state correspond to pion-like states which can be colored: this could bind the nucleons to form a nucleus. The evidence for the occurrence of cold fusion in living matter gives support for the role of dark nuclear strings [K72] [L45]. One can consider several representations of the genetic code in this framework.

Consider first models for which letters are represented separately.

1. Dark protons and neutrons have 4 spin states and could correspond to letter A,T,C,G. In this case dark color bonds would not matter. A rather convincing proposal for a pathway leading to a selection purines as DNA nucleotides has been proposed [I78]. TGD based model [L42] suggests that acidic solutions contain dark protons and purine results when the precursor amine combines with dark proton such that the proton remains dark. Could DNA nucleotide pair with dark protons and neutrons (resulting in dark beta decay from dark proton strings yielded by Pollack's mechanism)?
2. Also the 4 states of dark color bonds between dark nucleons (3 pion-like states and one eta meson like state: spin 1 bonds would be analogous to ρ and ω mesons and have higher mass) correspond to letters A,T,C,G. Now the dark protons and neutrons would not matter. This option would require that the character of the nucleotide correlates with the color flux tube attached to the dark proton. They would have at their ends charge conjugate color bonds. The states would be of form $u\bar{u}, d\bar{d}, u\bar{d}, d\bar{u}$ with the ordering of q and \bar{q} correlating with the direction in which transcription and replication take place being thus same or opposite). For conjugate strand the direction of strand would be opposite in the sense that one would have $\bar{u}u, \bar{d}u, \bar{d}u, \bar{u}u$.

For this option one could consider the strands of dark DNA double strand being connected by flux tube pairs resulting when U-shaped color flux tube have reconnected. If color flux

tubes are colored, color confinement could bind the dark protons to dark nucleus. Similar mechanism could be at work for the ordinary nuclei.

The basic problem of all the proposals based on letter-wise correspondence is that they do not even try to explain the numbers of DNA codons coding for a given amino-acid and are also silent about tRNA.

Codon-wise representations of genetic code realized in terms of dark strings

For this option entire codons rather than letters would be represented. The difference between two representations is analogous to that between spoken and written languages. In spoken languages words are not analyzed further to letters. These models are able to predict also the numbers of codons coding for a given amino-acid successfully.

1. The geometric theory of harmony represents codons as 3-chords without assigning fixed notes to A,T,C,G and explains also DNA-amino-acid correspondence.
2. The map of codons to the dark nucleon states of dark nucleon consisting of dark u and d type quarks does the same and also predicts the degeneracies successfully.
3. This model can be modified by replacing u and d by dark nucleon states p and n without any change in predictions related to genetic code. The evidence that DNA codons indeed couple to dark nucleon states [L42] supports this option.

In the sequel I consider the models mapping DNA codons to dark nucleons and then generalize the model so that it applies to triplets of dark nucleons.

6.5.2 Codons as dark quark-triplet strings

Water memory is one of the ugly words in the vocabulary of the main stream scientist. The work of pioneers is however now carrying fruit. The group led by Jean-Luc Montagnier, who received Nobel prize for discovering HIV virus, has found strong evidence for water memory and detailed information about the mechanism involved [K58, K132], [I102]. The work leading to the discovery was motivated by the following mysterious finding. When the water solution containing human cells infected by bacteria was filtered in purpose of sterilizing it, it indeed satisfied the criteria for the absence of infected cells immediately after the procedure. When one however adds human cells to the filtrate, infected cells appear within few weeks. If this is really the case and if the filter does what it is believed to do, this raises the question whether there might be a representation of genetic code based on nano-structures able to leak through the filter with pores size below 200 nm.

The question is whether dark nuclear strings might provide a representation of the genetic code. In fact, I posed this question year before the results of the experiment came with motivation coming from the attempts to understand water memory. The outcome was a totally unexpected finding: the states of dark nucleons formed from three quarks can be grouped to multiplets in one-one correspondence with 64 DNAs, 64 RNAs, and 20 amino-acids and there is natural mapping of DNA and RNA type states to amino-acid type states such that the numbers of DNAs/RNAs mapped to given amino-acid are same as for the vertebrate genetic code.

Could DNA and amino-acids correspond to dark quark triplet strings

The dark model emerged from the attempts to understand water memory [K58]. The outcome was a totally unexpected finding [L3, K58]: the states of dark nucleons formed from three quarks connected by color bonds can be naturally grouped to multiplets in one-one correspondence with 64 DNAs, 64 RNAs, 20 amino-acids, and tRNA and there is natural mapping of DNA and RNA type states to amino-acid type states such that the numbers of DNAs/RNAs mapped to given amino-acid are same as for the vertebrate genetic code.

The basic idea is simple. The basic difference from the model of free nucleon is that the nucleons in question - maybe also nuclear nucleons - consist of 3 linearly ordered quarks - just as DNA codons consist of three nucleotides. One might therefore ask whether codons could correspond to dark nucleons obtained as open strings with 3 quarks connected by two color flux tubes or as

closed triangles connected by 3 color flux tubes. Only the first option works without additional assumptions. The codons in turn would be connected by color flux tubes having quantum numbers of pion or η .

This representation of the genetic would be based on entanglement rather than letter sequences. Could dark nucleons constructed as string of 3 quarks using color flux tubes realize 64 DNA codons? Could 20 amino-acids be identified as equivalence classes of some equivalence relation between 64 fundamental codons in a natural manner? The codons would be not be anymore separable to letters but entangled states of 3 quarks.

If this picture is correct, genetic code would be realized already at the level of dark nuclear physics and maybe even in ordinary nuclear physics if the nucleons of ordinary nuclear physics are linear nucleons. Chemical realization of genetic code would be induced from the fundamental realization in terms of dark nucleon sequences and vertebrate code would be the most perfect one. Chemistry would be kind of shadow of the dynamics of positively charged dark nucleon strings accompanying the DNA strands and this could explain the stability of DNA strand having 2 units of negative charge per nucleotide. Biochemistry might be controlled by the dark matter at flux tubes.

The ability of the model to explain genetic code in terms of spin pairing is an impressive achievement, which I still find difficult to take seriously.

1. The original model identifying codons to dark nucleon states assumed the overall charge neutrality of the dark proton strings: the idea was that the charges of color bonds cancel the total charge of dark nucleon so that all states uuu, uud, udd, ddd can be considered. The charge itself would not affect the representation of codons. Neutrality assumption is however not necessary. The interpretation as dark nucleus resulting from dark proton string could quite well lead to the formation the analog of ordinary nucleus via dark beta decays [L45] so that the dark nucleus could have charge. Isospin symmetry breaking is assumed so that neither quarks nor flux tubes are assigned to representations of strong $SU(2)$.

There is a possible objection. For ordinary baryon the mass of Δ is much larger than that of proton. The mass splitting could be however much smaller for linear baryons if the mass scale of excitations scales as $1/h_{eff}$ as indeed assumed in the model of dark nuclear strings [L29, L45].

2. The model assumes that the states of DNA can be described as tensor products of the four 3-quark states with spin content $2 \otimes 2 \otimes 2 = 4 \oplus 2_1 \oplus 2_2$ with the states formed with the 3 spin triplet states $3 \otimes 3 = 5 \oplus 3 \oplus 1$ with *singlet state dropped*. The means that flux tubes are spin 1 objects and only spin 2 and spin 1 objects are accepted in the tensor product. One could consider interpretation in terms of ρ meson type bonding or gluon type bonding. With these assumptions the tensor product $(2 \otimes 2 \otimes 2) \otimes (5 \oplus 3)$ contains $8 \times 8 = 64$ states identified as analogs of DNA codons.

The rejection of spin 0 pionic bonds looks strange. These could however occur as bonds connecting dark codons and could correspond to different p-adic length scale as suggested by the successful model of X boson [L47].

One can also ask why not identify dark nucleon as as closed triangle so that there would be 3 color bonds. In this case $3 \otimes 3 \otimes 3$ would give 27 states instead of 8 ($\oplus 1$). This option does not look promising.

3. The model assumes that amino-acids correspond to the states 4×5 with $4 \in \{4 \oplus 2 \oplus 2\}$ and $5 \in \{5 \oplus 3\}$. One could tensor product of spin 3/2 quark states and spin 2 flux tube states giving 20 states, the number of amino-acids.
4. Genetic code would be defined by projecting DNA codons with the same total quark and color bond spin projections to the amino-acid with the same (or opposite) spin projections. The attractive force between parallel vortices rotating in opposite directions serves as a metaphor for the idea. This hypothesis allow immediately the calculation of the degeneracies of various spin states. The code projects the states in $(4 \oplus 2 \oplus 2) \otimes (5 \oplus 3)$ to the states of 4×5 with same or opposite spin projection. This would give the degeneracies $D(k)$ as products of numbers $D_B \in \{1, 2, 3, 2\}$ and $D_b \in \{1, 2, 2, 2, 1\}$: $D = D_B \times D_b$. Only the observed degeneracies

$D = 1, 2, 3, 4, 6$ are predicted. The numbers $N(k)$ of amino-acids coded by D codons would be

$$[N(1), N(2), N(3), N(4), N(6)] = [2, 7, 2, 6, 3] .$$

The correct numbers for vertebrate nuclear code are $(N(1), N(2), N(3), N(4), N(6)) = (2, 9, 1, 5, 3)$. Some kind of symmetry breaking must take place and should relate to the emergence of stopping codons. If one codon in second 3-plet becomes stopping codon, the 3-plet becomes doublet. If 2 codons in 4-plet become stopping codons it also becomes doublet and one obtains the correct result $(2, 9, 1, 5, 3)!$

This simple observation would suggest that genetic code could be realized already at the level of dark or even ordinary nuclear physics and bio-chemistry is only a kind of shadow of dark matter physics.

Objections against the identification of codons as dark quark triplets

Consider next some particle physicist's objections against the option mapping codons to dark nucleon states.

1. The realization of the model of codon as dark quark triplet requires the dark scaled variants of spin 3/2 baryons known as Δ resonance and the analogs (and only the analogs) of spin 1 mesons known as ρ mesons. The lifetime of these states is very short in ordinary hadron physics. Now one would have a scaled up variant of hadron physics: possibly in both dark and p-adic senses with latter allowing arbitrarily small overall mass scales. Hence the lifetimes of states could be scaled up.
2. Both the absolute and relative mass differences between Δ and N resp. ρ and π are large in ordinary hadron physics and this makes the decays of Δ and ρ possible kinematically. This is due to color magnetic spin-spin splitting proportional to the color coupling strength $\alpha_s \sim .1$, which is large. In the recent case α_s could be considerably smaller - say of the same order of magnitude as fine structure constant $1/137$ - so that the mass splittings could be so small as to make decays impossible.

The color magnetic spin interaction energy give rise to hyperfine splitting of quark in perturbative QCD is of form $E_c \propto \hbar g B / m$, where m is mass parameter which is of the order of baryon mass. Magnetic flux scales as \hbar by flux quantization and if flux tube thickness scales as \hbar^2 , one has $B \propto 1/\hbar$. Mass splittings would not depend on \hbar , which does not make sense. Mass splitting becomes small for large \hbar if the area of flux quantum scales as \hbar^{2+n} , $n > 0$ so that color magnetic hyper-fine splitting scales as $1/\hbar^n$ from flux conservation. The magnetic energy for a flux tube of length L scaling as \hbar and thickness $S \propto \hbar^{2+n}$ has order of magnitude $g^2 B^2 L S$ and does not depend on \hbar for $n = 1$. Maybe this could provide first principle explanation for the desired scaling.

The size scale of DNA would suggest that single DNA triplet corresponds to 3 Angstrom length scale. Suppose this corresponds to the size of dark nucleon. If this size scales as $\sqrt{\hbar}$ as p-adic mass calculations suggest, one obtains a rough estimate $\hbar/\hbar_0 = 2^{38}$. The proton- Δ mass difference due to hyper-fine splitting would be scaled down to about $2^{-38} \times 300 \text{ MeV} \sim 10^{-9} \text{ eV}$, which is completely negligible in the metabolic energy scale .5 eV. If the size of dark nucleon scales as \hbar the mass difference is about 12 eV which corresponds to the energy scale for the ionization energy of hydrogen. Even this might be acceptable.

For these reasons the option mapping codons to dark nucleon triplets is clearly favored and will be discussed in the following.

6.5.3 Codons as dark nucleon-triplet strings?

The assumption that entire codon rather than letter corresponds to a state of dark proton does not conform with the model for the origin of purines as DNA nucleotides [L42] assuming that purines,

and in fact all nucleotides, are combined with dark proton unless one assumes that 3 nucleotides combine with the same dark proton. This looks somewhat artificial but cannot be excluded.

The arguments of the model involve only the representations of rotation group and since p and n have same spin as u and d , the arguments generalize to 3- nucleon states (ppp, ppn, pnn, nnn) connected by two color bounds and organized to linear structures. Concerning genetic code, exactly the same predictions follow in the recent formulation of the model. In this case quark color is not present. One could however use the 1-dimensionality and the ordering of dark nucleons as already described.

The model with linear quark triplets generalizes by replacing dark u and d quarks with dark nucleons p and n . The analogs of ρ mesons would correspond to 2 bonds also now. Irrespective of changes of nucleons, all states would have decomposition $(4 \oplus 2 \oplus 2) \otimes (5 \oplus 3)$ corresponding to the degrees of freedom associated with 3 nucleon spins and 2 neutral ρ meson spins.

ppp could correspond to DNA and RNA and proton charges would neutralize the negative charges of ordinary DNA codons. The singlet formed by bonds would be neglected. nnn triplets could correspond to amino-acids and tRNA. Amino-acids could correspond to $4 \times 5 = 20$ and the remaining states $4 \otimes 3 \oplus (2 \oplus 2) \otimes 5 \oplus 3$ could correspond to 44 tRNAs. Also other options are possible and have net charges 2 and 1.

This variant has several nice features. The model is consistent with the model for dark nucleon strings consisting of nucleons and color bonds between them. There is no need to introduce Δ type nucleon states and colored states are not needed in fermionic sector. Color bonds must be colored if one wants ordinary bosonic statistics for flux tubes but here braid statistics might help. Colored bonds could of course have some important function.

Could dark DNA, RNA, tRNA and amino-acids correspond to different charge states of codons?

If dark codons correspond to dark nucleon triplets as assumed in the following considerations there are 4 basic types of dark nucleon triplets: ppp, ppn, pnn, nnn . Also dark nucleons could represent codons as uuu, uud, udd, ddd : the following discussion generalizes as such also to this case. If strong isospin/em charge decouples from spin the spin content is same independently of the nucleon content. One can consider the possibility of charge neutralization by the charges assignable to color flux tubes but this is not necessarily. In any case, one would have 4 types of nucleon triplets depending on the values of total charges.

Could different dark nucleon total charges correspond to DNA, RNA, tRNA and amino-acids? Already the group representation content - perhaps correlating with quark charges - could allow to distinguish between DNA, RNA, tRNA, and amino-acids. For amino-acids one would have only 4×5 and ordinary statistics and color singlets. For DNA and RNA one would have full multiplet also color non-singlets and for tRNA one could consider $(4 \oplus 2_1 \oplus 2_2) \times 5$ containing 40 states. 31 is the minimum number of tRNAs for the realization of the genetic code. The number of tRNA molecules is known to be between 30-40 in bacterial cells. The number is larger in animal cells but this could be due to different chemical representations of dark tRNA codons.

If the net charge of dark codon distinguishes between DNA, RNA, tRNA, and amino-acid sequences, the natural hypothesis to be tested is that dark ppp, ppn, pnn , and nnn sequences are accompanied by DNA, RNA, tRNA, and amino-acid sequences. The dark beta decays of dark protons proposed to play essential role in the model of cold fusion [?] could transform dark protons to dark neutrons. Peptide backbones are neutral so that dark nnn sequence could be also absent but the dark nnn option is more natural if the general vision is accepted. There is also the chemically equivalent possibility that only dark protons are involved: dark proton + neutral color bond would represent proton and dark proton + negatively charged color bond would represent neutron. At this moment it is not possible to distinguish between these two options.

Is this picture consistent with what is known about charges of amino-acids DNA, RNA, tRNA, and amino-acids? Consider first the charges of these molecules.

1. DNA strand has one negative charge per nucleotide. Also RNA molecule has high negative charge. This conforms with the idea that dark nucleons accompany both DNA and RNA. DNA codons could be accompanied by dark ppp implying charge neutralization in some scale and RNA codons by dark ppn . The density of negative charge for RNA would be $2/3$ for that for DNA.

2. Arg, His, and Lys have positively charged side chains and Asp, Glu negative side chains (see <http://tinyurl.com/jsphvgt>). The charge state of amino-acid is sensitive to the pH value of solution and its conformation is sensitive to the counter ions present. Total charge for amino-acid in peptide however vanishes unless it is associated with the side chain: as in the case of DNA and RNA it is the backbone whose charge is expected to matter.
3. Amino-acid has central C atom to which side chain, NH_2 , H and COOH are attached. For free amino-acids in solution water solution $\text{NH}_2 \rightarrow \text{NH}_3^+$ tends to occur pH=2.2 by receiving possibly dark proton whereas COOH tends to become negatively charged above pH= 9.4 by donating proton, which could become dark. In peptide OH attach to C and one H attached to N are replaced with peptide bond. In the pH range 2.2-9.4 amino-acid is zwitterion for which both COOH is negatively charged and NH_2 is replaced with NH_3^+ so that the net charge vanishes. The simplest interpretation is that the ordinary proton from negatively ionized COOH attaches to NH_2 - maybe via intermediate dark proton state.
4. The backbones of peptide chains are neutral. This conforms with the idea that dark amino-acid sequence consists of dark neutron triplets. Also free amino-acids would be accompanied by dark neutron triplets. If the statistics is ordinary only 4 dark nnn states are possible as also 5 dark color flux tube states.
5. tRNA could involve dark pnn triplet associated with the codon. An attractive idea is secondary genetic code assigning RNA codons to tRNA-amino-acid complex and projecting $8 \otimes (5 \oplus 3)$ containing 64 dark RNA spin states to $8 \otimes 5$ containing 40 dark tRNA spin states with same total nucleon and flux tube spins. Dark tRNA codons would in turn be attached to dark amino-acids by a tertiary genetic code projecting spin states $8 \otimes 5$ to $4 \otimes 5$ by spin projection. In the transcription dark tRNA would attach to dark mRNA inducing attachment of dark amino-acid to the growing amino-acid sequence and tRNA having only dark tRNA codon would be left. The free amino-acids in the water solution would be mostly charged zwitterions in the pH range 2.2-9.4 and the negative charge of COO^- would be help in the attachment of the free amino-acid to the dark proton of tRNA codon. Therefore also the chemistry of free amino-acids would be important.

An interesting question is why pnn triplets for tRNA would only 5 in flux tube degrees of freedom entire 8 in nucleon degrees of freedom. For RNA consisting of ppn triplets also 3 would be possible. What distinguishes between ppn and pnn?

The model should explain the widely different properties of DNA, RNA, tRNA, and amino-acids. There are two options.

1. DNA/RNA/amino-acid codons could correspond to ppp/ppn/nnn and tRNA would correspond to pnn (order is not necessarily this). Different charge or dark codons explain why DNA (RNA) has H (OH) in 2' position. The repulsive Coulomb energy between dark codons would be stronger for DNA and the compensation of this forces by the magnetic tension associated with the flux tube pair connecting codon and anticodon this might have something to do with the stability of DNA double strand.
 - (a) The instability of RNA as compared to DNA would result from the instability of the ribose in RNA (deoxiribose in DNA) as indeed believed. The absence of RNA double strands could be due to the instability of the flux tube pair assignable to n-n. This trivially implies absence of replication and transcription if it is based on same mechanism as in the case of DNA.
 - (b) pnn structure could explain why tRNA does not form sequences and allow to understand wobble pairing, which states that the third mRNA codon does not correspond to unique tRNA anticodon but one has $\text{C,A,U} \rightarrow \text{I}$ and $\text{U} \rightarrow \text{I}$. Due to the symmetries of the third letter of the codon, this is consistent with the genetic code. The physical explanation for wobble base pairing could relate to pnn structure of tRNA. If the charge ordering is random one would have nnp, npn, pnn and $\text{C,A,U} \rightarrow \text{I}$ could correspond to these 3 situations whereas for $\text{U} \rightarrow \text{I}$ the correspondence would not depend on the ordering.

Also for RNA one would have ppn, pnp, npp degeneracy but in this case one would have charge independence.

A possible charge pairing between RNA and tRNA would be $p \leftrightarrow n$. The charge pairing between DNA and RNA could be $p \rightarrow n$ for the third least significant letter of DNA. This would minimize the coding errors possibly induced this pairing.

- (c) One can criticize the charge assignment ppn (possibly allowing permutations) for RNA codons. Could dark weak beta decays give rise to 1-D lattice like structure? Could the repetitive structure be due to energy minimization.
2. Could the correspondence be letterwise? For DNA A,T,C,G would correspond to p, and for RNA A,C,G to p and U to n. Codons not containing U would be ppp type codons and one can wonder why the oxiribose for them is not replaced with de-oxiribose. The possible presence of n in dark codons could explain why RNA sequences are highly unstable and why they do not replicate and transcribe.

Objections based on group theory and statistics

The quark-triplet model and its generalization replacing u, d with nucleon states p, n works nicely but is better to try to invent objections against the proposal and try to find inconsistencies. Fermi and Bose statistics are the most obvious providers of killer arguments.

1. The basic objection is that if the quarks are organized in linear structures, one cannot talk about representation of 3-D rotation group since symmetry breaking to $SO(2)$ acting along common axis which could be either the local axis along dark DNA helix of the axis of the entire helix. The linear ordering of the quarks is not consistent with the full harmonics. Rather, harmonics restricted to half space $0 \leq \theta \leq \pi/2$ ($\pi \geq \theta \geq \pi/2$) should characterize the “upper” (“lower”) flux tube direction at the position of quark in the middle.

If reflection along quantization axis and $SO(2)$ generate the symmetries one still has labelling of the states by angular momentum projection and states form doublets $(m, -m)$. The representations of $SO(3)$ split into these representation and the numbers of states with given spin projection remain the same. Therefore the predictions for the numbers of DNA codons coding given aminoacid are not changed. It is quite possible that braid statistics made possible by 1-dimensionality is needed to realize the idea about ordering and this would allow to have full DNA multiplets.

2. In quark model one forms tensor product of tensor products of 3 quark spin states and 3 quark isospin states and by color singletness requires that the state is completely antisymmetric in quark degrees of freedom. The state is completely symmetric in the non-colored degrees of freedom. One obtains only two representations $\Delta \leftrightarrow (3/2, 3/2)$ and $N = (1/2, 1/2)$ with positive parity. In quark model context the presence of other tensor products in $(4 \oplus 2_1 \oplus 2_2)_S \otimes (4 \oplus 2_1 \oplus 2_2)_I$ is forbidden. One reason is that spatial wave function is assumed to be symmetric in ground state. This forbids 2_2 in spin degrees of freedom. Symmetrization leaves only the Δ and N (Note that the total number of these state is 20!). Now strong isospin is broken and it is natural to not include it to the tensor product.
3. The presence of 2_2 would be forbidden in quark model since it would require antisymmetric spatial wave function to compensate for the antisymmetry of 2_2 . In the recent case the situation is 1-dimensional and the ordering along nuclear string forces localization of quarks and one cannot have identical wave functions for quarks.

1-D situation also suggests strongly braid statistics. Perhaps the situation could be understood in terms of fermionic oscillator operators along nuclear string having anti-commutation relations corresponding to non-trivial braid statistics - maybe making the statistics commutative. This could naturally allow anti-symmetrization along nuclear string for 2_2 states.

4. If one assumes ordinary statistics, one could one take care of the statistics of the 16 states in $2_2 \otimes (5 \oplus 3)$ by assuming that for 2_2 the color state is symmetric and thus 10-D representation of $SU(3)$. The state associated with color flux tubes cannot compensate this color (triality is

- 1) since it must correspond to triality zero representation. If the colors of DNA strand and conjugate correspond to 10 and $\bar{10}$ and color entanglement could guarantee color singletness for the codon pairs. This would however require anti-quarks for the conjugate strand.
- 3 10:s associated with 3 codons contains in their tensor product a singlet (see <http://tinyurl.com/zjxxqhj>). Minimal color singlet dark DNA sequence would require 3 color codons. One can of course wonder whether the presence of 3 decouplet codons - 2 at the beginning and 2 at end and one in the middle could define genes as basic units.
5. The statistics problem is encountered also for the flux tubes. 5 (and 1) as symmetric representation is allowed by statistics but triplet is antisymmetric and thus not allowed. Again braid statistics might help. If one assumes that the flux tubes are colored - say color octets - and color wave function for flux tube pairs is antisymmetric, one can achieve Bose statistics for 3. Flux tube pair would correspond to $8 \in \{8 \times 8\}$ and minimum of two flux codons would be needed for color singletness in flux tube degrees of freedom.
6. For the counterparts of amino-acids one has only $4 \otimes 5$ allowed also by statistics considerations assuming color singlets. Could distinction between DNA/RNA and amino-acids related to statistics, perhaps braid statistics. The suggested role of braid strands possibly connecting DNA double strands and DNA double strands and lipid layers of cell membrane encourages the question whether the DNA strand and its conjugate entangle via the reconnection of the color flux tubes defining U-shaped “tentacles” to a flux tube pair connecting the strands. For amino-acids they would not be needed. Same could happen in the transcription process of DNA to mRNA and in the translation process for mRNA tentacles and those associated with tRNA.

Ordinary or braid statistics?

There are four options to consider: ordinary/braid statistics (1/2) and dark nucleon as dark quark/nucleon triplet as representation of DNA codon (a/b). One has options 1a,1b,2a,2b. Options 1b and 2b are at this moment the only options, which can be taken seriously: the reason is that dark protons would neutralize the negative charges of ordinary DNA nucleotides.

- Option 1a: codons as quark-triplets with ordinary statistics. For the ordinary statistics amino-acid like dark nucleons are color singlets. Part of DNA codons are represented as dark nucleons and would be colored and 10-D representation of SU(3). Dark amino-acids need not have color bonds with dark parts of other colored biomolecules like DNA, RNA, with exception possible formed by dark tRNA. DNA double strand could realize color confinement via the reconnection of color flux tubes.
- Option 1b: codons as nucleon-triplets with ordinary statistics. Option 1b requires in ordinary statistics for antisymmetric doublet and antisymmetric wave function for the 3 nucleons not allowing constant valued wave function also disfavored by the linear ordering. This condition might have the same implications as braid statistics.
- Options 1a and 1b. DNA is the only molecule that appears as double strands. A possible explanation is that codons and anticodons are paired by U-shaped flux tubes associated with the color bonds of dark DNA to form color singlets. Nucleonic colors would sum up to zero along the strand.
- Option 2a. For braid statistics it could be possible to avoid colored states of nucleon and flux tubes.
- Option 2b. The 3-nucleon codons would have no color and amino-acids could obey braid statistics reducing to ordinary statistics. This would not be the case for DNA/RNA.

It must be admitted that the situation is unsatisfactory as far as statistics is considered. For the option 1b) with codons identified as dark proton triplets one can however consider the following variant to satisfy statistics requirement.

1. Years after writing the above comments it has become clear that adelic physics [L55] brings in additional discrete degrees of freedom assignable to the group algebra of Galois group of extension of rationals inducing the extensions of p-adic number fields appearing in the adele.
2. Galois group acts on the space of space-time surfaces, and one can say that one has wave function at the orbit of the Galois group consisting of space-time sheets. At quantum level quantum states correspond to wave functions in the group algebra of Galois group of extension.
3. The role of color in helping to achieve correct statistics could be taken by Galois degrees of freedom. One can even consider the notion of Galois confinement as a generalization of color confinement [L98] binding codons as dark proton triplets to dynamical units. Even genes as sequences of codons could be bound to dynamical units as Galois singlets.

6.5.4 Further considerations

Replication, transcription, translation

The formation of flux tube pairs between molecules would be central in replication and transcription and in all bio-catalysis. Dark DNA would replicate first to dark DNA or mRNA. This requires that the building bricks of dark DNA and mRNA emerge from environment perhaps by mechanism involving reconnection for the magnetic tentacles and reduction of h_{eff} bringing the molecules near each other. Flux tube pairs between dark DNA codons and their conjugates (individual dark RNA codons) would be formed during replication (transcription). The formation of flux tube pair between mRNA and dark tRNA part of tRNA would bring tRNA to mRNA, where amino-acid would associate with the growing amino-acid sequence.

For options 1a and 1b based on ordinary statistics color singletness condition could play an important role in the replication and transcription.

1. If the value of h_{eff} before reconnection and contraction of flux tube dictating the scale of color confinement is large enough, colored dark nucleons could float as free - possibly colored states - in the environment for option 1a). For option 1b dark nucleons could be present in environment - this could relate directly to the ionization in electrolyte. For options 1a and 1b dark codons representing dark tRNA molecules would accompany them.
2. For options 1a) and 1b) color confinement in flux tube degrees of freedom by forming dark color flux tube pairs between dark DNA and its conjugate in codon-wise manner could give rise to DNA double strands as chemical shadows of dark double strands. The coupling between codon and anticodon would be defined by the condition that the total color bond spins of paired codons are opposite. Quark color could be compensated for option 1a along DNA strand: 3 10:s give singlet. One can of course ask whether dark DNA RNA sequences exist rather than being built during replication and transcription.

Are sound-like bubbles whizzing around in DNA essential to life?

I got a link to a very interesting article [I87] about sound waves in DNA (see <http://tinyurl.com/z7hod9b>). The article tells about THz de-localized modes claimed to propagate forth and back along DNA double strand somewhat like bullets. These modes involve collective motion of many atoms. These modes are interpreted as a change in the stiffness of the DNA double strand leading to the splitting of hydrogen bonds in turn leading to a splitting into single strands. The resulting gap is known as transcriptional bubble propagating along double strand is the outcome. I do not know the interpretation as sound wave is.

It has been proposed that sound waves along DNA give rise to the bubble. The local physical properties of DNA double strand such as helical structure and elasticity affect the propagation of the waves. Specific local sequences are proposed to favor a resonance with low frequency vibrational modes, promoting the temporary splitting of the DNA double strand. Inside the bubble the bases are exposed to the surrounding solvent, which has two effects.

Bubbles expose the nucleic acid to reactions of the bases with mutagens in the environment whereas so called molecular intercalators may insert themselves between the strands of DNA. On

the other hand, bubbles allow proteins known as helicases to attach to DNA to stabilize the bubble, followed by the splitting the strands to start the transcription and replication process. The splitting would occur at certain portions of DNA double strand. For this reason, it is believed that DNA directs its own transcription.

The problem is that the strong interactions with the surrounding water are expected to damp the sound wave very rapidly. Authors study experimentally the situation and report that propagating bubbles indeed exist for frequencies in few THz region. Therefore the damping does not seem to be effective. How this is possible? As an innocent layman I also wonder how this kind of mechanism can be selective: it would seem that the bullet like sound wave initiates transcription at many positions along DNA. The transcription should be localized to a region assignable to single gene. What could guarantee this?

Can TGD say anything interesting about the mechanism behind transcription and replication?

1. In TGD magnetic body controls and coordinates the dynamics. The strongest hypothesis is that basic biochemical processes are induced by those for dark variants of basic bio-molecules (dark variants of DNA, enzymes,...). The belief that DNA directs its own transcription translates to the statement that the dark DNA consisting most plausibly from sequences of dark proton triplets ppp at dark magnetic flux tubes controls the transcription: the transcription/replication at the level of dark DNA induces that at the level of ordinary DNA.
2. If the dark DNA codons represented as dark proton triplets (ppp) are connected by 3 flux tube pairs, the reverse of the reconnection should occur and transform flux tube pairs to two U-shaped flux tubes assignable to the two dark DNA strands. Dark proton sequences have positive charge $+3e$ per dark codon giving rise to a repulsive Coulomb force between them. There would be also an attractive force due to magnetic tension of the flux tubes. These two forces would compensate each other in equilibrium (there also the classical forces due to the negatively charged phosphates associated with nucleotides but these would not be so important).

If the flux tube pairs are split, the stabilizing magnetic force however vanishes and the dark flux tubes repel each other and force the negatively charged DNA strands to follow so that also ordinary DNA strand splits and bubble is formed. The primary wave could therefore be the splitting of the flux tube pairs: whether one can call it as a sound wave is not clear to me. Perhaps the induced propagating splitting of ordinary DNA double strand could be regarded as an analog of sound wave.

The splitting of flux tube pairs for a segment of DNA would induce a further splitting of flux tubes since repulsive Coulomb force tends to drive the flux tubes further away. The process could be restricted to DNA if the “upper” end of the split DNA region has some dark DNA codons which are not connected by flux tubes pairs. This model reasons why for dark proton sequences.

3. This model does not yet explain how the propagating splitting wave is initiated. Could a quantum phase transition increasing the value of h_{eff} associated with the flux tube pairs occur for some minimal portion of dark DNA “below” the region associated with gene and lead to the propagating wave induced by the above classical mechanism? That the wave propagates in one direction only could be due to chirality of DNA double helix.

An interesting question is how the RNA world vision (see <http://tinyurl.com/gpmxcmk>) relates to this general picture.

1. There are strong conditions on the predecessor of DNA and RNA satisfies many of them: reverse transcription to DNA making possible transition to DNA dominated era is possible. Double stranded RNA exists <http://tinyurl.com/y9mex4v7> in cells and makes possible RNA genome: this would however suggest that cell membrane came first. RNA is a catalyst. RNA has ability to conjugate an amino-acid to the 3' end of RNA and RNA catalyzes peptide bond formation essential for translation. RNA can self-replicate but only relatively short sequences are produced.

2. TGD picture allows to understand why only short sequences of RNA are obtained in replication. If the replication occurs at the level of dark ppn sequences as it would occur for DNA in TGD framework, long RNA sequences might be difficult to produce because of the stopping of the propagation of the primary wave splitting the flux tube pairs. This could be due to the neuron pairs to which there is associated no Coulomb repulsion essential for splitting.
3. In TGD framework RNA need not be the predecessor of DNA since the evolution would occur at the level of dark nucleon strings and DNA as the dark proton string is the simplest dark nucleon string and might have emerged first. Dark nuclear strings would have served as templates and biomolecules would have emerged naturally via the transcription of their dark counterparts to corresponding bio-polymers.

Is bio-catalysis a shadow of dark bio-catalysis based on generalization of genetic code?

Protein catalysis and reaction pathways look extremely complex (see <http://tinyurl.com/kp3sdlm>) as compared to replication, transcription, translation, and DNA repair. Could simplicity emerge if biomolecules are identified as chemical shadows of objects formed from dark nuclear strings consisting of dark nucleon triplets and their dynamics is shadow of dark stringy dynamics very much analogous to text processing?

What if bio-catalysis is induced by dark catalysis based on reconnection as recognition mechanism? What if contractions and expansions of U-shaped flux tubes by h_{eff} increasing phase transitions take that reactants find each other and change conformations as in the case of opening of DNA double strand? What if codes allowing only the dark nucleons with same dark nuclear spin and flux tubes spin to be connected by a pair of flux tubes?

This speculation might make sense! The recognition of reactants is one part of catalytic action. It has been found in vitro RNA selection experiments that RNA sequences are produced having high frequency for the codons which code for the amino-acid that these RNA molecules recognize (<http://tinyurl.com/kp3sdlm>). This is just what the proposal predicts!

Genetic codes DNA to RNA as $64 \rightarrow 64$ map, RNA to tRNA as $64 \rightarrow 40$, tRNA to amino-acids with $40 \rightarrow 20$ map are certainly not enough. One can however consider also additional codes allowed by projections of $(4 \oplus 2_1 \oplus 2_2) \otimes (5 \oplus 3(\oplus 1))$ to lower-dimensional sub-spaces defined by projections preserving spins. One could also visualize bio-molecules as collections of pieces of text attaching to each other along conjugate texts. The properties of catalysts and reactants would also depend by what texts are “visible” to the catalysts. Could the most important biomolecules participating biochemical reactions (proteins, nucleic acids, carbohydrates, lipids, primary and secondary metabolites, and natural products, see <http://tinyurl.com/jlfxags>) have dark counterparts in these sub-spaces.

The selection of bio-active molecules is one of the big mysteries of biology. The model for the chemical pathway leading to the selection of purines as nucleotides [L42] assumes that the predecessor of purine molecule can bind to dark proton without transforming it to ordinary proton. A possible explanation is that the binding energy of the resulting bound state is higher for dark proton than the ordinary one. Minimization of the bound state energy could be a completely general criterion dictating which bio-active molecules can pair with dark protons. The selection of bio-active molecules would not be random after all although it looks so. The proposal for DNA-nuclear/cell membrane as topological quantum computer with quantum computations coded by the braiding of magnetic flux tubes connecting nucleotides to the lipids would lead to the idea that flux tubes being at O=bonds [K3].

Comparing TGD view about quantum biology with McFadden’s views

McFadden [I138] has very original view about quantum biology: I have written about his work for the first time for years ago, much before the emergence of ZEO, of the recent view about self as generalized Zeno effect, and of the understanding the role of magnetic body containing dark matter [K49, K50]. The pleasant surprise was that I now understand McFadden’s views much better from TGD viewpoint.

1. McFadden sees decoherence as crucial in biological evolution: here TGD view is diametric opposite although decoherence is a basic phenomenon also in TGD.

2. McFadden assumes quantum superpositions of different DNAs. To me this looks an unrealistic assumption in the framework of PEO. In ZEO it is quite possible option.
3. McFadden emphasizes the importance of Zeno effect (in PEO). In TGD the ZEO variant of Zeno effect is central for TGD inspired theory of consciousness and quantum biology. McFadden suggests that quantum effects and Zeno effect are central in bio-catalysis: the repeated measurement keeping reactants in the same position can lead to an increase of reaction rate by factors of order billion. McFadden describe enzymes as quantum mousetraps catching the reactants and forcing them to stay in same position. The above description for how catalysis catches the reactants using U-shaped flux tube conforms with mousetrap picture.

McFadden discusses the action of enzymes in a nice manner and his view conforms with TGD view. In ZEO the system formed by catalyst plus reactants could be described as a negentropically entangled sub-self, and self indeed corresponds to a generalized Zeno effect. The reactions can proceed in shorter scales although the situation is fixed in longer scales (hierarchy of CDs): this would increase the length of the period of time during which reactions can proceed and lead to catalytic effect. Zeno effect in ZEO plus hierarchies of selves and CDs would be essentially for the local aspects of enzyme action.

4. Protons associated with hydrogen bonds and electronic Cooper pairs play a universal role in McFadden's view and the localization of proton in quantum measurement of its position to hydrogen bond is the key step of enzyme catalysis. Also TGD dark protons at magnetic flux tubes giving rise to dark nuclear strings play a key role. For instance, McFadden models enzyme catalysis as injection of proton to a very special hydrogen bond of substrate. In TGD one has dark protons at magnetic flux tubes and their injection to a properly chosen hydrogen bond and transformation to ordinary proton is crucial for the catalysis. Typical places for reactions to occur are C=O type bonds, where the transition to C-OH can occur and would involve transformation of dark proton to ordinary proton. The transformation of dark proton to ordinary one or vice versa in hydrogen bonds would serve as a biological quantum switch allowing magnetic body to control biochemistry very effectively.

What about electronic Cooper pairs assumed also by McFadden. They would flow along the flux tube pairs. Can Cooper pairs of electrons and dark protons reside at same flux tubes? In principle this is possible although I have considered the possibility that particles with different masses (cyclotron frequencies) reside at different flux tubes.

McFadden [I138] has proposed quantum superposition for ordinary codons: This does not seem to make sense in PEO since the chemistries of codons are different) but could make sense in ZEO. In TGD one could indeed imagine quantum entanglement (necessary negentropic in p-adic degrees of freedom) between dark codons. This NE could be either between additional degrees of freedom or between spin degrees of freedom determining the dark codons. In the latter case complete correlation between dark and ordinary DNA codons would imply also the superposition of their tensor products with ordinary codons.

The NE between dark codons could also have a useful function: it could determine physically gene as a union of disjoint mutually entangled portions of DNA. Genes are known to be highly dynamical units, and after pre-transcription splicing selects the portions of the transcript translated to protein. The codons in the complement of the real transcript are called introns and are spliced out from mRNA after the pre-transcription (see <http://tinyurl.com/gmphzzy>).

What could be the physical criterion telling whether a given codon belongs to exonic or intronic portion of DNA? A possible criterion distinguish between exons and introns is that exons have NE between themselves and introns have no entanglement with exons (also exons could have NE between themselves). Introns would not be useless trash since the division into exonic and exonic region would be dynamical. The interpretation in terms of TGD inspired theory of consciousness is that exons correspond to single self.

Is there a connection between geometric model of harmony and nuclear string model of genetic code?

There should exist a connection between the geometric model of harmony and genetic code and the model of genetic code discussed.

1. Dark DNA strands could be connected by color flux tubes to form a double strand by reconnections of U-shaped color flux tubes. What would induce a codon-wise or letter-wise pairing of DNA codons and their conjugates represented as dark quark triplets to form double DNA strand? Cyclotron resonance could accompany reconnection (magnetic field strength would be identical and reconnection could occur).
2. One has the correspondence $\text{codon} \leftrightarrow \text{state of dark nucleon}$ or $\text{codon} \leftrightarrow \text{state of dark nucleon triplet}$. The geometric model of harmony and genetic code [L22] represents the codons as 3-chords. The 3-chord would be represented in terms of cyclotron frequencies of dark photons assignable to the 3 dark quarks (nucleons) in the state. Each quark-color bond pair (including the pion-like bond) could be in 12 states with corresponding cyclotron frequency mappable to the basic octave. The cyclotron frequency triplets would be same for codons and conjugates. The only manner to understand the scale is in terms of spectrum of magnetic field strengths for U-shaped flux tube pairs.

This would require 3 pairs of flux tubes between the dark codons of DNA strands. If the quarks inside linear dark proton are connected by color flux tubes (like protons in the model of dark nucleus). Reconnection for U-shaped flux tube connecting quarks would give rise to the double strand formed by dark proton strings. The magnetic field strength of the 3-flux tubes would be determined by the state of dark proton and would be same for DNA and RNA codons and also for RNA codons and corresponding tRNA-amino-acid complexes. The cyclotron frequencies would define a scaled up variant of Pythagorean scale projected to the basic octave [L22]. This option does not favor the idea about separate 4-letter code.

3. The geometric model for harmony is formulated in terms of orbits of the subgroups of the isometry groups of tetrahedral and icosahedral geometries. The DNAs coding particular amino-acid correspond to the orbit of the triangle of icosahedron corresponding to the amino-acid. The decomposition $60 \rightarrow 20 + 20 + 20$ suggests strongly decomposition of I to 20 Z_3 cosets containing 3 elements each other and in correspondences with the triangular faces of icosahedron.
4. The model of the genetic code just discussed relies on the model of dark nucleon based on group theory. The symmetric groups of Platonic solids are in turn associated with inclusion of hyper-finite factors and appear in Mc Kay correspondence, whose proof involves decompositions of $SU(2)$ representations to the representations of the discrete subgroups of Platonic solids. A further observation is that the numbers of elements for isometries of icosahedron and tetrahedron are 60 and 4 respectively: the sum is 64. Could the action of Z_3 leaving face invariant could be posed as an additional condition on amino-acids and reduce the amino-acid representation to $4 \otimes 5$.
5. In the geometric model of harmony genetic icosahedral $20+20+20$ part of the code involves a combination of three different Hamilton's cycles mapping 60 DNAs to 20 amino-acids: in terms of icosahedral group I and its coset space I/Z_3 these maps correspond to coset projections. Could the decomposition $(4 \oplus 2_1 \oplus 2_2) \otimes (5 \otimes 3)$ be understood in terms of a reduction to icosahedral and tetrahedral subgroups of rotation group or of their spin coverings.

In this process finite-dimensional representation of $SO(3)$ decomposes to a direct sum of representations of the discrete subgroup if its dimension is larger than any of the dimensions of representations of the finite sub-group (for basic facts about these see <http://tinyurl.com/ho4onbs>). One might hope that the decomposition of the representations of $SO(3)$ appearing in the above formula under icosahedral group and or tetrahedral group could allow to understand the emergence of DNA, RNA, tRNA, and amino-acids as kind of symmetry breaking.

6. In the geometric model of harmony 64-codon code [L22] is obtained as a fusion 60-codon code assignable to icosahedron + 4 codon code assignable to tetrahedron. There are actually two codes corresponding to tetrahedron and icosahedron as disjoint entities and tetrahedron glued to icosahedron along one face. The model explains the two additional amino-acids Pyl and Sec coded for a variant of the genetic code.

How could these two successful models relate to each other? In p-adic physics of cognition Platonic solids and polygons can be seen as discrete approximation for sphere [L43] and biomolecules could be understood as cognitive representation in the intersection of real and p-adic space-time surface consisting of algebraic points. Could one assign icosahedron and tetrahedron to a codon in some concrete manner? Could the attachment of tetrahedron to icosahedron along one face have concrete meaning? The answer seems to be negative.

1. One can about the interpretation of the 12 vertices of the icosahedron - how number 12 could be assigned with the genetic code? The vertices correspond to notes perhaps represented as magnetic field strength at the flux tubes assignable to color bonds. This field strength should be determined by the spin state of dark 3-nucleon. No concrete nuclear string counterpart seems to exist for the closed Hamiltonian cycle consisting of 12 notes and in case of tetrahedral extension of 13 notes. 12 vertices of icosahedron correspond to 12 notes and 20 faces to 3-chords so that there is not need for more concrete correspondence.
2. The attachment of tetrahedron to icosahedron would bring in further note very near to one of the notes of Pythagorean scale and corresponding 3-chords. This has concrete interpretation and there is no need to make this more concrete at the level of geometry of DNA. If icosahedron and tetrahedron are disjoint one obtains four additional codons. It seems that all these 4 3-chords be assigned with the 3 color bonds, one note for each of them. What distinguishes at the level of dark nucleon string the situations in which tetrahedron is attached and non-attached to the color bond? In presence of attachment there would be 1 shared 3-chord corresponding to stop codon assignable with the shared face. The 13:th note appearing in 4 3-chords differs very little from one of the notes of the icosahedral scale: this corresponds to the fact that 12 perfect quints do not quite give 7 octaves as already Pythagoras realized. Crazy question: Could this small difference relate to the small relative mass difference $(m_p - m_n)/m_p \simeq .0014$ making itself possible visible in cyclotron frequency scale? The idea does not seem plausible: $[(3/2)^{12} - 2^7]/2^7 \simeq .014$ is 10 times larger than $(m_p - m_n)/m_p \simeq .0014$.

The conclusion is that genetic code can be understood as a map of stringy nucleon states induced by the projection of all states with same spin projections to a representative state with the same spin projections (total quark spin and total flux tube spin). Genetic code would be realized at the level of dark nuclear physics and biochemical representation would be only one particular higher level representation of the code. A hierarchy of dark baryon realizations corresponding to p-adic and dark matter hierarchies can be considered. Translation and transcription machinery would be realized by flux tubes connecting only states with same quark spin and flux tube spin.

6.6 Field Codes Associated With Homeopathy And A Model For The Magnetic Body

Homeopathy involves also more complex aspects than mere entrainment and imprinting. Benveniste represents evidence for codes based on the modulations of the carrier frequency [I74, I75]. This kind of code brings in mind the magnetic pulse patterns inducing altered states of consciousness [J99]. Cyril Smith claims that the imprinted frequency can be an arithmetic function (sum or product) of the imprinting pair of frequencies [J28].

These claims of course look highly implausible in the reductionistic framework. The presence of magnetic bodies acting as intelligent intentional agents changes the situation in TGD Universe. Dark plasma oscillations patterns induced by state function reduction of charge entanglement by W MEs define an ideal representation for the code words inducing motor actions, and one ends up to a more detailed vision about how magnetic body receives and experiences sensory input from

the biological body and controls it using codes with code words expressed as plasma oscillation patterns transformed to ionic waves. The model for Priore's machine [I140, I167] allows to test these ideas.

6.6.1 Plasmoids As Primitive Life Forms Associated With Magnetic Bodies

In TGD framework plasmoids can be regarded as primitive life forms associated with rotating magnetic flux quanta, and it has been demonstrated that plasmoids seem to possess the basic characteristics of a living system [I147]. The plasma in question is dark plasma. BE condensates of ions defining dark plasmas represent more advanced life forms of this kind. Dark plasma oscillations define ideal representations for field patterns inducing ionic (say Ca^{++}) waves (by many-sheeted Faraday's law) in turn inducing generalized motor activities.

The possibility of charged entanglement induced by W MEs and generating Bose-Einstein condensates of exotic ions brings in a genuinely new element to the model of plasmoids discussed earlier as predecessors of biological life [K49, K50]. The notion has been already applied in the model of nerve pulse [K96]. One can speak about non-Abelian holograms at the level of dark matter with W bosons taking key role in the realization of motor actions and neutral bosons playing similar role in the realization of sensory and memory representations.

Plasmoids as rotating magnetic systems

If plasmoids rotate they generate em charge by the effect known already by Faraday but not explained satisfactorily by Maxwell's electrodynamics. In TGD framework vacuum charge density induces radial electric field inducing radial Ohmic current which is not divergenceless and hence charges the rotating magnet. Cell, DNA, and other sub-systems in living matter are usually negatively charged and the underlying reason could be the presence of rotating plasmoids around which biochemical life forms have evolved.

Also Searl device [H19], [H9] discussed in [K131] is a rotating magnetic system. In this case the charging of the system implies an effective loss of weight in Earth's electric field. Searl device is known to develop cylindrical magnetic walls [?]. According to TGD based model of Searl device [K131], the rotating magnetic walls represent a simple example of a magnetic body containing dark matter. The energy and angular momentum transfer from the magnetic flux walls generated by the rotation to the rotating system is assumed to explain the accelerated rotation of the system.

Dark plasma waves

Dark plasma waves have synchronously oscillating spatial patterns. Charge densities correspond to the order parameters of BE condensates of bosonic ions so that the introduction of the ion densities is not an idealization as in the non-quantum situation.

The dispersion relation of dark plasma oscillations in the lowest order approximation reads as

$$f_p = \sqrt{e^2 n / m} ,$$

where n and m are the number density and mass of plasma waves. In the case of dark plasma waves n corresponds to the density defined by the order parameter of the Bose-Einstein condensate of ordinary or exotic ions. The dispersion relation does not depend on wave vector at all so that the plasma wave recurs to the same pattern again and again and therefore provide ideal representations of mental images.

Since the notion of ionic density is not an idealization in case of dark plasma waves, it seems sensible to assign energy quantum to the dark plasma waves. Since plasma frequency is purely classical quantity the plasma energy $E_p = \hbar(k) f_p$ would scale as $\hbar(k)$ and an increasing hierarchy of plasma wave energies is predicted. These energies could define the metabolic energy quanta in the case of plasmoid life forms. These quanta can decay to $k_d = 0$ low energy quanta as they are used.

Plasma wave patterns could provide a realization for the control commands inducing motor activities and the energy of the plasma wave could be sucked from metabolic energy sources by time mirror mechanism (see **Fig.** <http://tgdtheory.fi/appfigures/timemirror.jpg> or **Fig. ??** in the appendix of this book) and dissipated in the realization of motor action as the plasma wave decomposes into r plasma waves at the lowest level of the hierarchy.

Quite large energies are involved at higher levels of dark matter hierarchy and the question arises whether there exist suitable sources of metabolic energy. The dropping of electrons from $k = 137$ atomic space-time sheets could provide metabolic energy quantum $E(137) \simeq 1$ keV. The dropping of electron from $k = 131$ space-time sheet would liberate energy $E(131) \simeq 64$ keV. The requirement that plasma wave energies correspond to zero point kinetic energies forces quantization of the densities of ions for Bose-Einstein condensates. Also the cyclotron transition energies of electrons or their Cooper pairs can provide the metabolic energy quanta. Note that metabolic efficiency requires quantization of the densities of Bose-Einstein condensates.

In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant \hbar_{eff} so that cyclotron energy would be liberated.

A further source of metabolic energy could be dark microwave photons generated by quartz crystals in the rock. Callahan has found that rocks consisting mainly of quartz SiO_2 serve as a source of bio-photons and that paramagnetic soil implying strong Schumann resonance amplitudes is favorable for the well-being of plants [I48]. Bio-photons could be produced as de-coherence products of dark microwave photons. Interestingly, SiO_2^- ion has cyclotron frequency 10 Hz for the nominal value $B_E = .5$ Gauss of the Earth's magnetic field equal to the fundamental bio-rhythm and the p-adic frequency $f(2, 127)$ associated with the memetic code.

It is possible to assign definite time scales to various plasma densities in magnetosphere possibly relevant to consciousness and this in principle makes it possible to build a more detailed view about quantal magnetosphere.

Dark plasma wave patterns as a tool of bio-control

Dark plasma wave patterns correspond to small deviations of charge densities from the non-equilibrium charge density by exotic ionization. Charge entanglement by W MEs with the magnetic body is an ideal mechanism for the generation of these deviations.

W ME generates oscillatory entanglement with coefficients which depend on space-time coordinates. In the state function reduction one of the outcomes is a state in which Bose-Einstein condensates in both systems carry exotic nuclear em and weak charges.

The reduction occurs for entire Bose-Einstein condensates of bosonic ions at biological body. The stronger the W field, the higher the probability that exotically charged BE condensate results. Ionic BE condensates define the pixels of the motor map as well as sensory map and the size of coherence region determines the pixel size. Similar mechanism works at the level of sensory input to the magnetic body.

Dark plasma waves induce ordinary ionic waves such as Ca^{++} waves as asymptotic self-organization patterns which would naturally correspond to generalized motor actions. Plasma wave patterns generate also cyclotron radiation the interaction of which with Josephson junctions induce a sensory representation for these patterns so that the control loop closes. Digital spatial and temporal modulation of the plasma wave patterns makes possible field codes for motor activities induced by ionic waves. Obviously the coding of plasma wave patterns to motor actions would be very robust.

6.6.2 Field Representations Of Information Using Codes

As already mentioned, the work of Benveniste [I74, I75], Gariaev [I85], and Persinger [J99] provides evidence for the existence of field codes and for the view that water can learn associations [I44]. The basic distinction as compared to the genetic code is that field codes could be context dependent

conventions somewhat like natural languages since magnetic body brings in conscious intelligence and flexibility. Therefore the earlier vision about memetic code [K56] assuming strict duration of the memetic codons could be un-necessarily restrictive.

Information theoretic aspects

Code words are names for biological functions which can be very complex.

1. Associative learning of the code

Flexibility is the basic property of the field codes. The codes can be therefore context dependent and characterize individual organism rather than being biological invariants. Personal code might well be necessary in order to guarantee that biological body cannot be “possessed” by outsiders. The higher the level of dark matter hierarchy, the higher this flexibility is expected to be (natural language in contrast to primitive signals which are rather universal). The work of [I74, I75] and the report of Smith about context specified 7-bit code for frequency importing [J28] provide support for the associative learning in water.

Flexibility implies that an associative learning of the code is required. There are two diametrically opposite ways to understand what the establishment of the code could mean.

1. The definitely higher IQ and quantum flexibility of the magnetic body suggests that magnetic body learns by searching the patterns inducing the desired responses of the biological body.
2. Magnetic body could also teach, or rather modify, the biological body to respond in a desired manner to plasma wave patterns. This mode of learning requires plasticity and might be important at the level of brain: associative regions of the cortex of higher primates are indeed known to be highly plastic so that changes of connectivity could make possible this kind of learning. The learning requires feedback circuit. An input signal representing the motor action is dark plasma wave pattern. There is also a motor input modifying the response function of the biological body using already learned code. The feedback is essentially the output allowing to decide about next motor input modifying the response function. Automatic associative learning results if the control loop is made automatic. A fascinating possibility is that this kind of modification could occur at the level of genes as a kind of genetic self engineering.

Quite generally, spin glass degeneracy and classical non-determinism are prerequisites for learning at various levels of dark matter hierarchy. In neuroscience rewards and punishments represented by neurotransmitters and various information molecules are believed to drive the learning.

2. The information content of code is maximized

Negentropy Maximization Principle [K73] is expected to pose constraints on the possible codes but it is difficult to imagine deduction of these constraints directly from NMP. The number theoretic model reproducing the genetic code as well as its variants [K35] suggests much more direct approach.

Number theoretical variants of Shannon entropy allow interpretation as positive information measures. The information content of the code should be maximized by assigning to it somehow a statistical ensemble or a set of statistical ensembles. In the model of genetic code the 64 codons labelled by integers in the range 0, ..., 63 and the corresponding amino-acids are labelled by the 18 primes $p < 64$ and integers 0, 1 which correspond to DNAs labelled by 0, 1. Hence the task reduces to finding an assignment $n \rightarrow p(n)$. The prime associated with a given integer from the maximization of negentropy for the entire code. Dynamics is thermodynamics for the partitions of n to a sum of r integers, $r = 1, \dots, n$. Quantum criticality suggests that the Hamiltonian $H(r)$ (or rather, Boltzmann weights) can be engineered freely. The negentropy $N(n)$ is maximum over p -adic negentropies $N_p(n)$ (formally Shannon entropies) fixing the prime $p(n)$.

This principle generalizes to an arbitrary code provided one can label the codewords using integers n and their images by primes $p(n)$. In the model of the genetic code n codons code for 0, 1 and primes $p < n$, whose number $N(n)$ behaves for large values of n like $N(n) \simeq n/\log(n)$. This is obviously a highly non-trivial prediction about the code. The model as such does not tell anything about how the plasma oscillation patterns are labelled by integers.

The patterns to which codons are mapped should be effectively digital just as in the case of a computer graphics. Dark matter Bose-Einstein condensates react as single particles and serve as natural digits and the number of codons is finite. BE condensate patterns induce patterns of ionic waves (such as Ca^{++} waves), and if it is only the asymptotic self-organization pattern which matters, the degeneracy of the code follows naturally.

3. How the meaning emerges?

Information without meaning is not information. The model based on magnetic body and biological body allows to understand how the meaning of the symbolic signals used in the communications emerges. The biological self-organization process induced by the signal acting as a control signal give rise to a mental image at the level of biological body (symbolic mental image at the level of brain and sensory mental images at the level of sensory organs) shared by the magnetic body via entanglement. This mental image would give the meaning for the signal.

How magnetic body perceives?

In order to speak about perception as something more than a completely automatic process, it is necessary to assume that the perceiver is an intentional agent receiving sensory input and able to perform motor actions. Magnetic bodies at higher levels of dark matter hierarchy would be a natural identification for the recognizer.

1. The general model for motor action and sensory communications

The general model for motor actions and communications of sensory input to the magnetic body relies crucially on magnetic flux quanta connecting system to its magnetic body and Josephson junctions serving the role of sensory receptors. This model was first developed for cell with cell/nuclear membrane serving as Josephson junction and DNA double strand as a basic instrument of motor action allowing to realize motor commands via gene expression. An essential assumption is the presence of quantum critical high T_c super-conductivity, or actually two kinds of super-conductivities possible in some finite temperature range for which a good guess is 36-37 °C [K44]. The model assigns to the cell membrane and its scaled up variants a hierarchy of Josephson junctions and generalized EEGs. $k_d = 47$ corresponds to the 5 Hz frequency of EEG.

This model allows to develop a model of sensory perception using the patterns of Josephson radiation. The model of Comorosan effect [?] suggests that even molecules could be carriers of supra currents and that the structures formed by enzymes and substrate molecules contain Josephson junctions. Hence the model might apply even when the perceiving system is the magnetic body of bio-molecule, say that of a molecular motor. In the case of DNA double strand the identification of the candidates for Josephson junctions is obvious.

Josephson junction codes information about all kinds of radiation to the pattern of Josephson radiation. In particular, the dark cyclotron radiation generated by the cyclotron transitions of the cyclotron BE condensates at the magnetic bodies creates a voltage perturbation and thus affects Josephson current in the Josephson junctions assignable with the recognizing system and the resulting Josephson radiation received by the magnetic body contains information about the cyclotron radiation emitted by the target.

2. How magnetic body perceives the sensory input from the biological body?

An important question is how the magnetic body generates the cyclotron radiation to which the biologically important molecules respond. In the vicinity of Earth (say below ionosphere) this radiation could be generated by the ions themselves but at high enough heights it is basically protons and electrons which are present in significant amounts.

An elegant resolution of the problem would be provided by the model of frequency imprinting and entrainment. Exotically ionized super-nuclei formed by protonic strings dropped to magnetic flux sheets are able to mimic ordinary ions. These super-nuclei could also act as receiving antennas and can serve as kind of amplifiers in the recognizing system. Time mirror mechanism would also allow to amplify phase conjugate signal using population reversed cyclotron laser.

3. Sensory input from biological body as a somatosensory map at magnetic body

The basic recognition process is related to the recognition of the patterns of Josephson

radiation consisting of frequencies $f_{n,\pm} = nf_c \pm f_J$. Somehow these patterns must define what might be called somatosensory maps at the level of magnetic body.

The previous work with frequency coding of positions of objects of perceptive field using varying cyclotron frequencies [K98] suggests that the magnetic field at the magnetic flux quanta is slowly varying so that the input at frequency $f_{n,\pm} = nf_c \pm f_J$ generates resonant cyclotron transitions at a position of the magnetic flux quantum determined by the condition $\hat{f}_c = f_{n,\pm}$.

This would map the sensory input to a geometric pattern along magnetic body defined by the varying intensity of induced cyclotron transitions and magnetic body would experience the input from the biological as a kind of bodily sensation. It is quite possible that same sensory input is mapped to several positions at the magnetic body.

The harmonics of “alpha” band would correspond to $\hat{f}_c = nf_c$ and would correspond to motor areas of the magnetic body disjoint from sensory areas. “beta” and “theta” bands would correspond to $nf_c + f_J$ and $nf_c - f_J$ and receive sensory input. This allows two options.

1. The magnetic flux could vary in discrete manner so that $\hat{f}_c = nf_c$ would corresponds to magnetic flux $n\hbar(k)$: in this case the harmonics of alpha band would correspond to disjoint flux quanta within which magnetic field varies in a relatively narrow range. In this case EEG bands would have precise geometric correlates.
2. If the magnetic flux has minimal value of $\hbar(k)$, the area of the magnetic flux quantum would vary as $S(n) \propto 1/\sqrt{n}$ by flux quantization. There would be a cutoff in n since the field strength cannot be too high.

If the magnetic field strength decreases as a function of distance from Earth as one might expect, beta and gamma bands would be nearer to the biological body than theta and delta bands for both options. This conforms with the fact that the EEG activity above alpha band is typically associated with rapid reactions and the time delay due to the sensory communications should be minimal. The magnetic body can extend below the Earth’s surface where the field strength increases.

The role of brain would be to construct symbolic representations by abstracting only the essential features of the sensory input so that also pattern completion would become possible. Magnetic body itself would accept the sensory input from brain and body as such.

Dark plasma wave patterns as motor commands

Since dark plasma waves recur again and again to the same pattern they are ideal for the field representation of codewords representing biological activities. Dark plasma oscillations can induce various ionic waves such as Ca^{++} and Mg^{++} waves since plasma wave modifies the scalar potential at dark space-time sheets and thus also at ordinary space-time sheets by Faraday law in many-sheeted space-time. Plasma wave pattern generates also a pattern of cyclotron radiation in the magnetic field and its presence is detected at the magnetic body via sensory system so that a motor-sensory feedback loop results.

Dark plasma wave patterns would define self-organizing “motor mental images” assignable to the biological body and perhaps also with motor areas of magnetic bodies since the motor control of magnetic bodies from higher levels is also expected to be present. These self-organization patterns would represent control commands realized in terms of frequencies and spatial field patterns assignable to W MEs. Digitalization would be implied by the size of the coherent region of the BE condensate making collective quantum phase transition to a state involving plasma oscillation with a probability proportional the intensity of W field inside coherence region.

The realization of motor action involves W MEs. Exotic W bosons behave as massless particles below the weak length scale but above this scale they possess a mass obtained by radically scaling down the mass ~ 80 GeV of the ordinary $k = 89$ W boson. This suggests that a large metabolic energy of order W boson mass is needed to generate W ME and that this energy transformed to the energy of plasma oscillation as charge entanglement is reduced and produces exotic ionization. This metabolic energy could be provided by the dropping of an electron from atomic or sub-atomic space-time sheet to a larger space-time sheet.

6.6.3 Priore's Machine As A Test Bench For The Model

Theoretician encounters often inventions which work but seem to defy all attempts to understand them. Even more, it seems a complete mystery how the inventor has ended up with his device, unless one accepts the idea that the inventor was working under the guidance of some higher level conscious entities. Priore's machine demonstrated to heal cancer certainly belongs to this category. Although the biological effects of the Priore's device are described in high detail, the construction of the machine, which is very complicated, is described in a very sketchy manner [I167]. This makes it difficult to see what is essential and what is not. In the following the model for bio-control is taken as a guideline in attempts to understand why Priore's machine works.

Three approaches to the cure of cancer

One can approach the cure of cancer from at least three different directions.

1. *Cure the cancer cells*

The general vision about biological evolution as emergence of higher levels of dark matter hierarchy suggests that some higher levels in the hierarchy of magnetic bodies are lacking in the case of cancer cell population so that cells become lonely individuals having replication as the sole purpose of life. Dysfunction at the level of super-genes looks a plausible reason for the asocial behavior. Magnetic flux sheets corresponding to some super genes could be lacking so that "social" control from some magnetic bodies in the hierarchy would fail. A possible cure of cancer would be healing of the cancer cells by super-gene therapy: something probably not possible for a long time even if the concept made sense.

The basic problem could be the absence of a magnetic body responsible for the quantum bio-control at some levels of the p-adic and dark matter hierarchies. The cure would be the restoration of this magnetic body by using external magnetic fields. The control of this magnetic body by higher level magnetic bodies should be mimicked by inducing periodic modulations of the magnetic field strength with frequencies which correspond to important bio-rhythms. The functioning of Priore's machine supports this interpretation.

2. *Help immune system in its task*

The presence of cancer cells is not a fatal problem if immune system is intact. The simplest reason for the failure of the immune system to eliminate cancer cells would be that it does not possess metabolic resources or that it lacks "soldiers" doing the dirty jobs, or messengers mediating commands to the battle field. Perhaps the restricted metabolic energy resources do not allow to generate plasmoids realizing the control commands from higher levels of the immune system as plasma wave patterns. In this case a possible cure would be the introduction of metabolic energy from outside and generation of additional plasmoids. Priore's machine seems to stimulate the immune system somehow and there is no detectable direct effect on the replication of the cancer cells. Thus this strategy could be realized by Priore's machine to some extent.

3. *Could cancer be cured by editing the geometric past?*

The earlier attempt to understand the functioning of Priore's machine was based on the idea that cancer cells realize some biological program ("replicate", more or less) plus the hypothesis that control commands correspond to holograms and the reversals of these commands to phase conjugates of the holograms. This allows to imagine the possibility of curing cancer by using the phase conjugate of the command "replicate".

This does not however work. The simple reason is that the general model for the realization of intentions implies that *all* motor actions are realized in terms of phase conjugate MEs, in particular negative energy W MEs inducing charge entanglement. The phase conjugate of the motor command would thus represent communication of sensory information rather than negation of the motor command. This duality between passive and active aspects of consciousness seems rather deep and has remained without sufficient attention hitherto.

One can however consider the possibility of sending the motor command "do not replicate" to a sufficiently distant geometric past or a command for an immune system to eliminate the replicators more effectively than it does in the recent geometric past. This would be essentially editing of geometric past affecting also the geometric now and could induce rather dramatic quantum

jumps in which the state of patent would suddenly change. Highest levels of dark matter hierarchy consistent with the duration of the human life cycle should be involved which suggests that this kind of healing is based on spiritual practices indeed claimed to induce miraculous healings. Indeed, in the case of Priore's machine the time scales involved are so fast that there is no reason to believe that it could send motor commands to the immune system of the distant geometric past.

Description of the device

Consider first the main points related to the structure and function of the device.

1. Plasma is present

Priore's machine is a tube containing rotating plasma. Ions of Ne and Argon gas are used. No information about how complete the ionization is given although the field used is enough to ionize $n = 3$ electrons in the case of Argon. The estimate for the pressure is given but temperature is not reported so that it is not possible to make reliable estimates about the density of the plasma.

The voltage $V = .43$ kV voltage generates the plasma in the tube. Argon and Neon are reported to be used as plasma gases. For Argon ionization energy is $E_1 \sim 18^2 \times 13.6 \text{ eV} = 4.405 \text{ keV}$. The ionization of $n = 3$ electrons with energy $E_3 = E_1/9$ is possible by the electrons accelerated in the voltage and gaining thus maximal energy of .49 keV if dissipative effects can be neglected. 8-fold ionization is possible for Ar since the energies of $n = 3$ electrons are nearly degenerate. For Ne the potential ionizing electrons at $n = 2$ shell would differ by a factor $(3 \times 10/2 \times 18)^2 = 25/36 \simeq .7$ from that for Ar. Also Hg plasma is mentioned [I140]: the tube is reported to be 2 mmHg vacuum: my interpretation is that it contains 2 millimoles of Hg that is 1.2×10^{21} Hg atoms per tube volume. For Hg the ionization energy of $n = 6$ electrons would be about 5 times higher than for Ar so that 5 times higher voltage would be needed.

2. Cyclotron frequencies of Ar and Ne ions are equal to the cyclotron frequency of Ca ion

The observation which puts bells ringing is that Ar^{++} and Ne^+ have same cyclotron frequency as Ne^+ as Ca^{++} . The radiation at the cyclotron frequency of Ca^{++} is known to have effects on living matter [J104], and TGD based model for these effects led to the model for the hierarchy of generalized EEGs associated with the dark matter hierarchy [K44].

3. Plasma is rotating

A rotating deflector to which ions arrive induces a rotation of the plasma in the direction of the axis of the cylindrical cavity. Rotation frequency f is reported to be below 100 rpm ($f \leq 1.7 \text{ Hz}$). Rotation makes the plasmoids charged by an effect known already by Faraday. Also Searl device is a rotating magnetic system and its charge explains the reported effective loss of weight as being due to the interaction with the Earth's radial electric field. Searl device is also known to develop cylindrical magnetic walls [H19, H9]. According to the TGD based model of the Searl device the rotating magnetic walls represent a simple example of a magnetic body containing dark matter. In this case the dropping of electrons from atomic space-time sheet to a larger space-time sheet provides the energy for the accelerated rotation and for the formation of magnetic walls. Also transfer of angular momentum to magnetic walls is in principle possible.

The rotation of the plasma with the magnetic flux lines frozen to the plasma could create a similar situation, and the rotating magnetic walls could receive metabolic energy from the dropping of electrons and provide it for the immune system whose stimulation seems to be involved with the healing. Also the magnetic field in the region of target would rotate so that plasmoids containing biologically important dark ions could be generated also here.

4. Magnetic field of order kGauss is present

Magnetic field of order kGauss is present also in the target. 620 Gauss and 1240 Gauss are the typical field values used. It would be nice to understand why the strength of the magnetic field used is what it is. The ratio of the magnetic field $B_1 = 612 \text{ Gauss}$ to the dark magnetic field $B_d = .2 \text{ Gauss}$ playing key role in the TGD based model of living matter is $B_1/B_d = 2^{11+1/2}$ with 5 per cent accuracy, which suggests that p-adically scaled up version of this magnetic field corresponding to the p-adic length scale $k = 169 - 23 = 146 = 2 \times 73$ could be in question.

The external magnetic field is modulated between some limits with the period of heart beat in the optimal situation. Hence the values of magnetic fields at which biological effects occur could differ from the nominal values. For $B_{end} = .2$ Gauss the cyclotron energies of all biologically important ions are above thermal threshold if the magnetic flux quanta correspond to $k_d \geq 43$ levels of dark matter hierarchy. For 62 Gauss magnetic field this holds true for $k_d \geq 33$ and for 1240 Gauss for $k_d \geq 32$. Note that one has $h_{eff} = nh$, where n is product of distinct Fermat primes and power 2^{k_d} . For kHz frequency the lower bound is $k_d \geq 22$.

5. *Modulated microwave radiation is present*

Microwave radiation with frequency $f_1 = 9.4$ GHz modulated by a frequency $f_2 = 17$ MHz in a typical experiment is also present. The wavelengths used are in range 3 cm–80 cm corresponding to the range 10 GHz–.38 GHz. The optimal microwave frequency depends on the organ irradiated. Microwave radiation is crucially important and there are reasons to believe that its frequency can vary only in a narrow range. The intensity of the microwave radiation correlates strongly with healing effects. The presence of the modulation is necessary to achieve the healing effect. Several modulation patterns are used which suggests that control commands based on field code are involved.

6. *Also highly energetic charged particles are involved*

The system involves very high voltages generating highly energetic electrons and ions [I167]. These voltages are much higher than the ionization voltage for Ne and Ar or even Hg. Hence the highly energetic electrons and X rays could be essential also for the primary function of the Priore's machine. Highly energetic electrons and ions could give their energy for dark microwave photons. High energy X rays with energies $E \simeq 300$ keV would transform to dark microwave photons which in turn would be transformed to plasma oscillations. The patent of Priore mentions that a typical voltage $V = 300$ kV is present in the device [I167] so that electrons accelerated in this voltage could indeed provide the X rays transforming to dark microwave photons to dark plasma oscillations.

A proposal for the mechanism of healing

The model for the hierarchy of EEGs discussed in [K44] is a good starting point in the attempts to understand that role of the modulated microwave photons and external magnetic field. In this model Josephson radiation has energies in visible and UV range for the typical values of the resting potential. Frequency modulation of Josephson radiation is used to code information and frequency modulated Josephson radiation is also responsible for both the representation of sensory data at the magnetic body and motor control by magnetic body. Since the amplitude modulated microwave radiation is responsible for the healing effects the natural proposal is that it is transformed to dark photons with frequencies in the same range as Josephson radiation associated with the cell membrane.

1. Microwave photons have frequency $f = 9.4$ GHz. The corresponding photon energy is below the thermal threshold. The condition that the energy of the dark photons with this energy is the energy E_J of Josephson photon reads as

$$\frac{E_J}{eV} = .41 \times \frac{f}{10^{14} \text{ Hz}} \times r \quad . \quad (6.6.1)$$

For $r = 2^{16}$ one obtains $E = 2.66$ eV.

2. For electron the cyclotron frequency for $B_{end} = .2$ Gauss is $c_c(e) = 6 \times 10^5$ Hz. For $B = 620$ Gauss $= 3100B_{end}$ and for $r = 2^{16}$ the energy of cyclotron energy quantum is

$$\frac{E_c}{eV} = r \times \frac{B}{B_{end}} \times .41 \times \frac{f_c(e)}{10^{14} \text{ Hz}} = .49 \text{ eV} \quad . \quad (6.6.2)$$

This is the energy of metabolic energy quantum.

This observations would suggest that the mechanism involves both control signal and transfer of metabolic energy.

1. The amplitude modulated microwave photons transform to Josephson radiation coupling to some biologically important ion at cell membrane and transmit information in accordance with the finding that the modulation pattern is important.
2. The cyclotron photons associated with electrons at the magnetic flux tubes of the external magnetic field generate cyclotron radiation serving as a source of metabolic energy.

For the mechanism to work it is essential to have a desired value of Planck constant once the value of the magnetic field is fixed. This fixes theof the microwave photon energy and electron's cyclotron energy so that one has $f/B = \text{constant}$. $k_d = 16$ is the value in the case considered. The proposal is consistent with Mersenne hypothesis: the value of k_d corresponds to the pair $k = 151$ and $k = 167$ of Mersenne primes assignable corresponding to the size scale of 10 nm (cell membrane) and 250 nm (size of cell nucleus). It is important to notice that these scales correspond to electron Compton scales $L_e(k) = \sqrt{5}L(k)$ rather than p-adic length scales $L(k)$.

6.6.4 Fields And Genes

Fields and genes could relate in several ways. Field patterns could code for genes in the sense that W MEs would induce the Mg^{++} waves activating genes. Coding of genes by plasma wave patterns would be a higher level code in which genes take the role of amino-acids and plasma wave patterns that of genes. Genes could be also expressed as field patterns: introns are good candidates in this respect. There are claims that field patterns can induce genetic modifications: perhaps there are genes coding for genetic self engineering operations.

Coding of genes by plasma wave patterns

According to the dark matter inspired vision, magnetic bodies act as intentional agents inducing processes like DNA transcription and translation. The model for the findings of Gariaev [I85] led to the proposal that the radio wave spectrum emitted by DNA subject to irradiation by laser light could be a superposition of copies of EEG like spectra corresponding to various p-adic length scales. The spectrum suggests that cyclotron frequencies of Mg^{++} ions are present (25 Hz for ordinary EEG). Mg^{++} ions are indeed known to be important for the functioning of DNA. Therefore magnetic bodies could excite Mg^{++} waves use dark plasma oscillations induced by W MEs as control commands to excite Mg^{++} waves leading to the activation of various processes like translation and transcription. Perhaps even topological quantum computation like processes could occur [K4]. Each gene could be sensitive to a particular subset of Mg^{++} wave patterns and thus to a particular subset kind of W field patterns. The frequency assignable to W ME in turn correlating directly with its distance from magnetic body could be automatically select the correct group of genes.

In principle the coding of genes by plasma oscillation patterns could be context sensitive and perhaps the genome contains a subset of genes which are purely personal so that foreign magnetic bodies cannot activate them. Also the portions of hyper genes in given organism could be activated by plasma oscillation patterns characteristic for this organism. Language could correspond directly to this kind of oscillation patterns perhaps activating intronic portions of the genome to express itself in some un-orthodox manner, say processes involving RNA, field patterns, or topological quantum computation [K4].

At lower levels field codes are expected to be rather hard-wired just like computer languages or primitive languages consisting of signals. The codons of the memetic code could be realized as sequences of 21 DNA triplets at the intron level [K56] and corresponding plasma oscillation patterns might correspond directly to linguistic expressions.

If field codes are learned, the question arises whether also genetic code is learned in the same manner. Variations of the genetic code and the slight context dependency of some variants of the genetic code [K35] support the view that genetic code is probably also learned at very early stages of biological evolution. The deviations from universality would suggest that the maximization of the total information of the code occurs only locally in the space of all codes.

Is electromagnetic information represented using genetic code?

The TGD based model of the genetic code as a single code in a hierarchy of codes results from a model for abstraction process as a repeated formation of Boolean statements about Boolean statements [K56]. This process starts from two statements (0 and 1) and gives at the first step $2^2 - 1 = 3$ statements if one statement (represented set-theoretically by empty set) is thrown away. At the next steps one obtains by a similar procedure $2^3 - 1 = 7$, $2^7 - 1 = 127$, $2^{127} - 1$, etc. statements: the numbers of statements are obviously given by Mersenne numbers. The number of the mutually consistent statements is 1, 2, 4, 64, ... at various levels of the hierarchy and the interpretation of DNA and its conjugate as representations and their negations suggests itself as being associated with the level $M_7 = 127$. There are good reasons to assume that these codes are realized in many ways in living matter and can represent all kinds of information.

Smith gives in his article support for the existence of seven bit electric code emerging already at the level of frequency imprints in water making possible arithmetic operations for the external frequencies imprinted to water [J28]. The seven bit character of the code brings in mind the hierarchy of genetic codes predicted by TGD [K56] and encourages the conjecture that the sequences of 7 vacuum current pulses with single pulse representing either zero or one should provide an electromagnetic realization of the genetic code and its conjugate each consisting of 64 different pulse sequences and that a sequence and its Boolean conjugate represent command and its time reversal.

In his talk about water memory effects related to homeopathy Cyril Smith reported in CASYS2001 [J28] evidence for a context dependent 7-bit coding of binary arithmetic operations (addition, subtraction, multiplication and division) of two source frequencies, call them f_1 and f_2 , giving as a result the imprinted frequency $f(f_1, f_2)$. The experimental arrangement involves two frequency sources (f_1 and f_2) contained by beakers, a pulse generator and the "receiver". The arithmetic operation determining the frequency imprinted into water as a function $f(f_1, f_2)$ of f_1 and f_2 is coded by a pair of pulse sequences consisting of 7 pulses with 1 and 0 represented by the polarity of the electrical pulse.

1. For instance, when the beakers and receiver are (in this order) along East-West axis (Earth's magnetic field is important!) and connected serially to the pulse generator, the pulse sequence 1001001 1111111 codes for addition. When the receiver is replaced between the beakers connected to the pulse generator in a parallel manner, multiplication results.
2. When the beakers are in East-West direction and coupled serially to the pulse generator, 1000001 1111111 codes for subtraction. When the beakers are along North-South axis, the same sequence codes for division. f_1/f_2 or f_2/f_1 results depending on the order of the frequency sources connected in a serial manner to the pulse generator.
3. When the latter sequence 1111111 is replaced by 0000000, the imprint is in the "opposite phase" (biologically depressive instead of being stimulatory). Thus the latter sequence might tell whether genetic code or its conjugate is used and thus whether the imprinted frequency represents command or its time reversal realized as a reference wave giving rise to a hologram.

What one can conclude about the general structure of the code on basis of these experimental evidence?

1. The result of the arithmetic operation is context dependent and thus not coded completely by the binary sequence. As a consequence, single bit can code for the binary operation in question and 3+3 bits can be used to code for additional operations acting on each of the two arguments.
2. The structure of the code word should reflect the structure of the binary arithmetic operation, which is quite generally of form $(f_1, f_2) \rightarrow X f_1 O Y f_2$, where O denotes $+$, $-$, \times or $/$ and X and Y are operations acting on the arguments f_1 and f_2 .
 - (a) The requirement that the time reversal of the bit sequence also codes for a binary operation fixes the general structure of the codeword to be $X O Y$ where X and Y have same length and O is thus in the middle of the codeword.

- (b) The context dependence of the operation implies that O can be represented by a single bit. $O = o_1$ in the middle of the codeword is indeed invariant under the time reversal. $O = 1$ signifies addition or multiplication whereas $O = 0$ signifies subtraction or division.
- (c) The 3-bit sequences $X = x_1x_2x_3$ and $Y = y_1y_2y_3$ should code for the possible operations performed for the arguments. Note that the number of bits is same as that for the codewords at the level $M_3 = 7$ below $M_7 = 127$. For commutative operations like $+$ and \times the time reversal of the codeword obtained by changing the order of the bits in the command should yield the same end result. This is the case if the time reversal $Y = X_T$ of X obtained by reversing the order of bits in X has the same effect on f_2 as X has on f_1 . $X = 100$ and $Y = 001$ appearing in the operations are indeed mirror images and have interpretation as identity operations. Besides identity operation 7 additional operations for the arguments are predicted to be possible (this brings in mind octonion units). Clearly, the pairs (X, Y) of operations correspond to 64 DNA code words and the arithmetical operation itself corresponds to the 7: th bit in the middle of the codeword.
- (d) The proposed structure of the codeword is consistent with the data reported in [J28]. In particular, the symmetry of the sequence 1000001 coding for a division with respect to the reversal of the bits is compensated by the asymmetry induced by the exchange of the beakers. In the case of subtraction the change of the order of beakers should change the sign of the imprinted frequency: does this mean that the effect of resulting frequency is changed to its time reversal?

Of course, one can pose several critical questions relating to the experimental arrangement. Has it been tested how the situation changes when the direction of the linear arrangement is not East-West or North-East? Does the outcome of the operation change continuously in this kind of operation? In how wide a range of frequencies the coding of the arithmetic operations has been verified? However, the mere demonstration that

1. the structure of the pulse sequences consisting of a pair of 7 pulses determines the imprinted frequency as function $f(f_1, f_2)$ of the source frequencies f_1 and f_2 and that
2. the effect of this frequency is changed from stimulatory to depressive by the binary conjugation of the binary sequence is consistent with the view that a realization of the genetic code by electromagnetic pulse sequences is in question and that reference wave and its phase conjugate induce opposite biological effects.

Is it possible to transfer genetic information using field patterns?

The work of Yu. Chen Kangeng gives evidence that the transfer of the genetic information by electromagnetic means is possible [J11]. According to [I84], where the method is summarized, the successful transfer of the genetic information from a donor bio-system to an acceptor system was achieved via high-frequency electromagnetic fields feed repeatedly through the optically-active donor bio-system and then delivered over a long period of time to the receiving bio-system in its early developmental stages. The hybrids created through the irradiation of eggs and seeds with such “genetically loaded” fields are claimed to show very specific mixed characteristics that were transferred to the next generation without need for further irradiation.

It would seem that the donor genome or parts of it are imprinted to the electromagnetic field pattern in the process and that this field pattern is able to modify the target genome.

Nothing precludes the possibility that genes/supergenes/hyper genes at some level of dark matter hierarchy can also code for genetic self engineering since these activities are after all very similar to other genetically coded bio-chemical activities. The computer analogy would be programs writing programs. The engineering genes would be activated by W MEs inducing plasma oscillation patterns. The claimed effects could be understood if the interaction with genetically imprinted electromagnetic field pattern activates genes inducing genetic self engineering yielding the genetic modifications consistent with the pattern represented by the em radiation.

Magnetic body would receive information about the desired outcome as electromagnetic field patterns emitted by other organisms, most naturally members of the same species. If these modifications are successful, the magnetic body is exposed to this information for long enough time to react and activate *W* MEs inducing the genetic program inducing the genetic program leading to the suggested genetic modification.

Hyper-genes integrating groups of organisms to larger wholes would be naturally involved with the mechanism. This mechanism would guarantee a rapid propagation of successful genetic modifications to the entire population and would be much more effective than the slowly occurring selection of random mutations. The possibly existing genes responsible for the genetic self engineering could be also introns and express themselves by activating nuclear RNA and process like reverse transcription.

The mechanism could explain the findings of Sheldrake about learning at the level of species. The observed rather recent emergence of 223 new genes into human genome [I66, I129] could be understood as a genetic self engineering rather than genetic engineering by more advanced civilizations as suggested in [K40] (note however that the higher levels of dark matter hierarchy can be also regarded as “more advanced civilizations”). A further quite recent mystery discussed in [K56] is that corals seem to possess genes responsible for higher level psychological functions in mammals [I93]: it is very difficult to understand this as an outcome of selective pressures combined with random mutations. The proposed mechanism might explain these genes as a result of genetic engineering.

The basic ingredient of the coral backbone is calcium carbonate $CaCO_3$. Salt is in question so that also Ca^{++} and CO_3^{-} ions are present. Ca^{++} could obviously give rise to Calcium waves. CO_3^{-} has atomic weight $A = 60$ with cyclotron frequency 10 Hz for the nominal value of the Earth’s magnetic field. This frequency defines the fundamental biological rhythm and characterizes also memetic code. It characterizes also effectively 2-dimensional waves closed inside the ionospheric cavity: for l^{th} harmonic the frequency is $f = \sqrt{l(l+1)}/2\pi R_E$, R_E Earth’s radius, and $l = 1$ gives 10 Hz frequency. Could the transfer of the genetic information in the Earth’s length scale with 126-bit memetic codons be realized as ripples 10 Hz waves make possible genetic self engineering of coral genome?

During the early developmental stages the genome might be plastic enough to allow genetic self engineering. The genetic modification during this period also the most rational option since this gives the best guarantee that the modifications are transferred to the offspring.

Could genes be expressed in terms of field patterns?

The previous considerations assume that genes are activated using field patterns. It is also possible to consider the possibility that genes are expressed in terms of field patterns. Introns which are chemically silent are excellent candidates in this respect and the notion of memetic code relies to the idea that intronic portions of genome consist of sequences of 21 DNA triplets defining memetic codons expressed electromagnetically. This would also fit nicely with the hypothesis that introns correspond to hyper genes. Note however that introns could also express themselves by activating processes involving nuclear RNA, in particular genetic self engineering. Even process like topological quantum computation can be assigned to introns.

6.6.5 Magnetic Mirrors, Remote Viewing And Remote Healing

Magnetic mirrors formed by the magnetic flux tube-ME pairs occur in many different contexts in TGD inspired theory of consciousness. Magnetic mirrors of length of order light life appear in the model of long term memory (when I, that is my magnetic body, looks at sufficiently distant mirror I see the me of the geometric past). Magnetic mirrors are crucial for the model of the sensory canvas and there seems to be no sharp difference between different types of memory which suggests that there is an entire hierarchy of memories in various p-adic time scales.

Dark matter hierarchy provides a classification for the memories in terms of the level of the dark matter hierarchy [K44], and it is possible to identify the time scale of sensory experience as a very short term memory with time of 1 seconds (in accordance with the findings of Libet), minute scale short term memory, a memory with a time scale of days, and what is usually regarded as long term memory in terms of the levels of the dark matter hierarchy.

Magnetic mirrors play a key role in the model of frequency imprinting and provide a general molecular recognition mechanism as well as model for how sensory percepts are communicated to the magnetic body and how magnetic body performs motor actions. Magnetic mirrors allow also a generalization of many-sheeted DNA so that magnetic mirrors represent genetic information in electromagnetic form.

The wide applicability of the magnetic mirror notion suggests in accordance with the fractality of consciousness that various functions associated with the magnetic mirrors are aspects of the same basic phenomenon. Magnetic mirrors would thus provide sensory canvases, long term memory mirrors and recognition mechanism at all length scales. Even many-sheeted DNA would possess sensory canvas and long term memories, perhaps an entire hierarchy of them. One can even consider the possibility that our long term memories are average over those associated with genes associated with various neurons!

Nothing in principle precludes the possibility that magnetic mirrors can also serve as bridges between different organisms: even the notion of organism must be generalized if the idea of multi-brained magnetic selves is taken seriously. The notions of super- and hyper genes give a concrete content for this generalization [K68, K44]. This could make possible effects similar to observed at DNA level (such as self assembly and translation of RNA to proteins). Why this kind of telepathic bridges are rarely realized in the post-modern society can be understood as a result price to be paid for the gradual individualization taken place during evolution from bacteria to bicamerality to modern consciousness: in the era of market economy it would not be wise to allow a direct access to your personal consciousness from outside.

A general model for remote viewing and healing

The last observation suggest also a general model for the phenomena like remote viewing and healing defying standard science explanations (see the article of Lian Sidorov [J93]). One healing method goes under name Qigong (see the article [J33]). Qigong is a general term for a large variety of traditional Chinese energy exercises and therapies. Qigong is generally considered as a self-training method or process through Qi (vital energy) and Yi (consciousness or intention) cultivation to achieve the optimal state of both body and mind. The traditional Chinese medicine postulates the existence of Qi, which could be regarded as a kind of subtle energy circulating around the physical body.

In TGD framework the energy associated with MEs and supra-currents flowing along magnetic circuitry would be a natural counterpart of Qi. Yi would in turn would translate to p-adic cognitive representations representing also intentions, perhaps p-adic variants of MEs. Internal Qigong refers to self healing whereas external Qigong means directing Qi energy or intention to help others by opening Qi blockages or inducing the sick Qi to get out of body, or helping to achieve Qi balance. The physiological, chemical and electromagnetic effects of both internal and external Qigong have been studied ([J93] contains large number of related references). Also the effects of Qigong healing on cancer has been studied [J33].

Skeptics tend to eliminate these effects from their consciousness simply by denying their reality or claiming that only placebo effects are in question. The deep irony is that placebo effect represents a basic example of this kind of effect. The basic psychological reason for this reactive attitude is very simple: only the understood phenomenon is an existing phenomenon. In TGD framework these phenomena can be indeed understood using a model generalizing the vision about endogenous bio-control so that the sender and receiver of the control signal can be different organisms. Thus independently whether the claimed effects are replicable not, this kind of effects are more or less predicted by TGD framework.

The general model for remote viewing and healing is roughly following.

1. Magnetic mirrors connecting the sender and receiver make possible a universal mechanism for the transfer of intent (Yi) and action (Qi). p-Adic MEs represent the transfer of a mere intent and real MEs represent a transfer of action. p-Adic ME can be transformed to real ME either by receiver or some higher level magnetic self.
2. The transfer of intent gives rise to a healing mechanism which can act both endo- and exogenously. ME-magnetic flux tube pairs characterized by their fundamental frequencies make possible bridges between healer and healee and allow a resonant interaction in which healer

can initiate various control commands or 4-dimensional templates represented as holograms. Also smaller MEs can be send along these MEs serving as bridges (this is like throwing balls with light velocity!).

3. The ME-magnetic flux tube pair connecting healer and healee acts as a reference wave which can initiate an arbitrarily complex hologram representing biological program. Healer has the ability to generate and amplify the frequencies which induce holograms representing the control commands. In particular, healer can initiate complex biological programs without knowing anything about their functioning.
4. It is quite possible that also multi-brained and -bodied higher level magnetic selves actively participate in the process.

Dark matter hierarchy and remote mental interactions

The ideas inspired by dark matter hierarchy allow a concretization of these ideas.

1. Charge entanglement as basic mechanism of remote mental interactions

The sharing of mental images could quite universally involve charge entanglement by W MEs so that remote mental interactions, the basic mechanism of intentional action, and exotic weak interactions would be very closely related.

Negative W MEs become also a basic tool of intentional interaction and the active party could in principle use the body of the subject person to realize his intentions. Hypnosis could rely on this mechanism. This could occur also in the case of healing, and the generalized motor commands would include gene expression. The body of the healee would provide the metabolic energy in this case.

There is a mental disorder in which patient mimics with an amazing authenticity the gestures of persons which she does not know beforehand. The neuro-scientific explanation would probably relay on exceptionally active/abundant mirror neurons. One can imagine two alternative quantum explanations: either the motor areas of the patient quantum entangle with those of the object of mimicry or the magnetic body of the object entangles with the motor areas of patient, whose magneto-immune system fails for some reason.

If the code defined by the proposed map of plasma oscillation patterns mediated by W MEs to generalized motor actions (induced by ionic waves) is not universal, the healer must use only the universal part of the code, be able to learn the personal code of the healee, or act with the mediation of collective levels of self hierarchy able to utilize “multi-person” codes. The universality might fail only at the higher levels of dark matter hierarchy where organisms become individuals.

2. Time mirror mechanism as energy source

The healee can suck metabolic energy from the healer by time mirror mechanism, that is by sending neutral negative energy MEs received by the healer or possible third party.

Remote mental interactions affecting non-biological targets would rely on same mechanisms, in particular charge entanglement by W MEs. For instance, capacitors with voltage near to a dielectric breakdown might be sensitive targets of remote mental interactions. The model of Priore’s machine suggests that remote mental interactions could affect and even generate plasmoids in rotating plasma.

3. Hierarchy of time scales associate with remote mental interactions

It is possible to assign to the remote mental interactions a hierarchy of time and length scales and in time scales shorter than human life cycle there are seven levels involved. This brings in mind chakra hierarchy. Since magnetic bodies at levels $k_{em} \geq 4$ have astrophysical size scale, the distance between the biological bodies of the healer and healee does not matter at these levels. The time scale remote viewing process would correspond to the time scale of entanglement identifiable as the time scale of the generalized EEG involved.

Comparison with data

The model of remote healing and vision proposed above seems to conform with the findings described in [J93] (the URL references of this article provide a comprehensive source of background data).

1. *Coordinate healing and healing using adjunct*

The basic observation [J42, J93] is that there are two classes of transfer of intent (including remote healing and vision as special cases).

1. The target is found by the remote healer or viewer being given a name, location, birthdate, etc. What is strange is that this information need not have any conscious meaning for healer. This can be understood if multi-brained magnetic selves are involved with the process so that it is enough that the information has meaning for some brain involved. The well-documented effects of prayer groups (see [J42] which gives various aspects of spiritual healing) could be understood if the higher level selves receiving information from all prayers are actively engaged in the process. Also a coherent amplification of the effect (the so called Maharishi effect in transcendental meditation proportional to the square of the number of participants) would be involved.
2. An adjunct (an object previously treated by the healer, such as water, cloth, a crystal, etc) is used by the healee with or without the healers's knowledge. Adjunct could act as a relay station being connected to the healer and healee by MEs containing same frequencies. Besides serving as relay station, the adjunct can also act as an antenna amplifying the healing frequencies. This would explain why water (LC water blobs), linear structures like lock of hair of healee containing DNA, and crystals are effective adjuncts. This also explains why remote viewer can have vision about the viewed by touching some object belonging to the viewed.

2. *The role of imagery*

The role of imagery is known to be important. The abilities of the sender to transmit the intent seem to be better the more vivid is his/her ability to imagine the intent. This conforms with the hypothesis that the transfer of intent involves at basic level the generation of a p-adic space-time sheet transformed to real form at some stage and that the transformation to a real action occurs in the easiest manner if the p-adic pseudo constants involved are genuine constants as for real solutions of the field equations.

2. *Two kinds of healing mechanisms seem to be involved*

TGD view conforms with the fact that two kinds of healing mechanisms seem to be involved. Healer either uses his own energy to influence the healee or uses "universal energy". In the first case healer herself would transform the p-adic intent into a real action. In the second case this transformation is carried out by the healee or some third agent, possibly higher level self.

3. *Distance does not seem to matter*

The model explains also how healing effects can be achieved over distances of thousands of miles. The basic characteristic of MEs is that they allow a directed propagation of classical energy without attenuation (Maxwell's equations do not allow this kind of solutions). Thus, if magnetic mirrors serve as bridges between the sender and receiver of intent, the high precision communication of intent does not look mysterious.

Lian Sidorov [J93] mentions the experiment performed by M. Sue Benford *et al.* (unpublished), where exposing half of a hair sample to a non-ionizing radiation produced radiographic film exposure underneath the other half of the sample, located many miles away. The explanation of this effect must be based on macroscopic entanglement. The basic idea is that the effect is analogous to spin measurement in Einstein-Rosen-Podolski experiment: that is, the measurement of the spin of an electron fixes the spin of the electron entangled with it. The simplest explanation that come in mind are following.

1. The exposure to the non-ionizing radiation reduced charge entanglement by dark W MEs between the two halves of the sample and that the resulting exotically ionized state produced the radiation leading to the exposure of the film.
2. In another experiment of Sue Benford [I162] (to be discussed in the next section) the intentional action of the experimenter is reported to induce dots and tracks in the photographic emulsion. It is not possible to exclude the possibility that the subconscious intentional action of the experimenter might have produced the exposure also in this experiment.

Variants of this experiment could provide a justification for the notion of macroscopic quantum entanglement. In particular, charge entanglement by W MEs could in principle be demonstrated by proving so simultaneous generation of opposite charges by state function reduction that it cannot be explained in terms of em currents flowing with sub-luminal velocity.

4. *Supra currents in astrophysical length scales as an alternative for charge entanglement*

A competing explanation for genuinely non-local generation of charge is charge transfer by supra currents along magnetic flux quanta. One could test also the hypothesis of super-conductivity in macroscopic length scale by using variant of this kind of experiment. For instance, a variant of this test is based in the addition isotopes of selected ions to other half of the sample and finding whether the fraction of ion isotopes increases in the second half of the sample located, say, at the second side of the globe. That supra-currents could flow in these length scales is in consistency with the magnetic sensory canvas model.

The model for auroras as an astrophysical quantum phenomenon discussed in [K23, K24] relies on the assumption that the magnetic flux tubes of both earth's and solar magnetic fields are super-conductors (solar wind would thus flow as supra currents). A topological model for the crucial reconnection phenomenon of the magnetic field lines of earth's and solar magnetic fields results. Recombination is accompanied by the leakage of the supra currents to nonconducting space-time sheets through flux tubes: this mechanism is a good candidate for a universal mechanism leading to breakdown of super-conductivity and is presumably involved with a wide class of atmospheric phenomena like lightnings, ball lightnings, tornadoes, etc.. The model allows to identify the mechanism generating the electric fields responsible for the acceleration of ions eventually giving rise to auroras via collisions with the ions of the ionosphere.

What is fascinating that the sounds claimed to be heard during auroras but not measured by micro-phones might represent genuine extrasensory percepts resulting from the perturbations of the magnetic auditory canvas caused by the auroras. The breakdown of the super conductivity might even correlate with the loss of consciousness reported to sometimes occur during perceiving auroras. This picture encourages to think that weather phenomena, in particular thunder storms, relate to our consciousness also in extrasensory manner.

5. *The effects of healers to the em frequency spectrum of water*

There is evidence that healers can affect the em frequency spectrum of water. In [J93] examples of these effects are listed: the Raman spectra of water can be influenced from a distance up to 1900 km; the polarization angle of He-Ne laser can be affected by so called waiqi method; the IR spectrum (hydrogen bonds) of sterile water changes in the proximity of therapeutic touch practitioners. Experiments do not support the hypothesis that the time of exposure correlates with the intensity of the effect. On the other hand, the treatment time of adjuncts is known to be an important factor in the distant healing. Also the UV spectrum of the water treated by healers differs from that for control samples.

It is not difficult to understand these effects in terms of W entanglement inducing an exotic ionization of dark Bose-Einstein condensates in turn inducing electric fields at the level of ordinary matter (recall the many-sheeted version of Faraday's law). Atoms with exotically ionized nuclei behave effectively like isotopes and have thus slightly different energy levels than their ordinary counterparts. This could serve as a test for the presence of exotic ions. Same applies to exotically ionized molecules.

The effects at UV frequencies could involve MEs with lengths shorter than 10^{-7} meters are involved and produced in de-coherence of dark photons to ordinary photons. Micro-tubules in UV length scale range are natural candidates for being accompanied by $k_d = 0$ UV MEs (for instance, the receptors in retina contain micro-tubuli in UV wave length range). The cell membrane could

contain an array of MEs of length $L_e(151) = 10$ nm parallel to lipids whereas genes should involve also MEs with lengths corresponding to the wave lengths of visible light [I82].

Especially interesting wave lengths for bio-photons in IR-UV range are the electronic Compton scales $L_e(151) = 10$ nm, $L_e(157) = 80$ nm, $L_e(163) = 640$ nm, and $L_e(167) = 2.52 \mu\text{m}$ which all correspond to Gaussian Mersenne primes (Mersenne primes are in a preferred role in elementary particle physics: all charged leptons, nuclei, hadrons and intermediate gauge bosons correspond to ordinary or Gaussian Mersennes). That these primes span all p-adic length scales between cell membrane thickness and cell length scale could be the number theoretic correlate for the miracle of life. Needless to emphasize, the finding that these frequencies are biologically special frequencies would give an enormous boost for TGD approach.

According to the original model the transfer of intent could involve sending of MEs with short lengths, say in UV or IR range: this would be like throwing a ball to a tunnel. The model based on de-coherence of dark MEs does not seem to require this. Be as it may, these MEs would move inside larger MEs forming the bridge between sender and receiver. $L_e(163) = .640 \mu\text{m}$, which is in the lower end of the visible portion of photon spectrum (.4 – .7 μm) and thus corresponds to red light, equals with 6 per cent precision with the wave length $\lambda = 644 \mu\text{m}$ associated with photosynthesis by chlorophyll b) and with 6 per cent precision to the wave length $\lambda = 680 \mu\text{m}$ associated with the photosynthesis by chlorophyll a). Could it be that magnetic mirrors with these wave lengths amplify photosynthesis by first amplifying the incoming visible light in a resonant manner?

6. Exotic weak force and biology

The basic prediction of TGD is entire hierarchy of exotic electro-weak and color physics corresponding to preferred p-adic length scales. These p-adic physics in turn involve dark hierarchy. It is clear that dark variants of exotic weak bosons would play key role in living matter. There is evidence that exotic weak interactions is involved with remote mental interactions. According to [J72], even radioactive decay rate of Am241 has been influenced by intent. There is evidence also for weak interactions in astrophysical length scales. The lifelong work of Russian scientist Shnoll demonstrates the fluctuations for the rates of various chemical and radioactive processes vary with periods related to astrophysical phenomena (see [E4], [E4] and [K16]. Exotic weak forces would also explain also the mysterious chiral selection occurring in living matter. These observations together with other applications of exotic weak forces encourage to think that weak MEs could have an important biological role.

Ordinary neutrinos seem to correspond to $k = 13^2 = 169$ space-time sheet. The quantum model of hearing revised so that it is consistent with the vision about dark matter [K95] forces to assume the existence of exotic neutrinos with $k = 127$ space-time sheet (electron length scale) coupling to $k = 113$ weak bosons. This encourages a generalization: perhaps leptons and quarks can reside in many length scales: for instance, at the space-time sheets $k = 151, 157, 163, 167$ corresponding to the biological Gaussian Mersennes. This assumption does not imply any conflict with what is known about weak and color interactions, in particular asymptotic freedom, since the bosons of different physics would couple directly only to the particles of their own physics.

There are several reasons to suspect that above atomic length scales several p-adic length scales can define copies of electro-weak and color physics and their dark variants. This is actually not new finding. The masses of low lying hadrons can be understood if the p-adic prime $p \simeq 2^k$, k integer, characterizing quark can depend on hadron [K79]. The poorly understood aspects related to the determination of top quark mass suggest that the p-adic length scale assignable to quarks can vary in a wide range [K74]. Also the mass scale of neutrinos seems to depend on environment [K69, K74]. In condensed matter physics the huge variations of electrons effective mass might be partly due the variation of the p-adic length scale assignable to electron.

7. The role of the magnetic fields

The treatment of water by magnetic fields is known to stimulate plant growth and to affect IR absorption spectra, surface tension and crystallization patterns. The effects resemble those achieved by the treatment of healer. The emission of bio-photons in IR and UV range have been frequently measured in the proximity of healers. This is easy to understand if MEs and magnetic fields form magnetic mirrors so that presence of either makes the presence of another probable. For instance, magnetic fields could stimulate the formation of plasmoids.

8. *The transfer of intent has EEG correlates.*

In one class of experiments described in [J93] the sender and receiver are located separately in sensory shielded rooms and extrasensory transfer of information is attempted while both sender and receiver are connected to electroencephalographs. The sender transmits his intent during randomly selected intervals and receiver attempts to guess the moments of transmission. Experiments demonstrate no conscious ability to guess the moment of transmission. However, a statistically significant correlation between the actual sending time and the alpha wave amplitude was found in the receiver.

alpha wave synchronization was detected between pairs of qigong masters and their receivers even when they were separated by a distance of 4 km. A possible interpretation is that the low frequency part of EEG, in particular alpha band (perhaps Schumann frequency) are used by the higher level multi-brained magnetic selves which act as relay stations receiving the intent of the sender and communicating it to the receiver. That alpha band is involved fits nicely with the fact that the cyclotron frequencies of most biologically important bosonic ions are in alpha band. Note that the energies of dark EEG quanta are above thermal threshold for $k_d \geq 40$.

This hypothesis is also natural since Schumann frequencies are associated with the oscillations of the magnetic flux quanta also representing sensory canvases and magnetic components of our selves (the quantum energies assignable to Schumann frequencies f_S would come as $E_S(k) = \hbar(k)f_S$). Note however that for the complex structures formed by the magnetic flux tubes of Earth's magnetic field also other resonance frequencies than Schumann frequencies are expected. The time lapse between the sending and onset of the unconscious physiological response in the receiver was found in these experiments to vary in the range 10–17 seconds: this would suggest that $k_d = 54$ level of the dark matter hierarchy is involved.

6.7 The Role Of Dark Micro Waves In Living Matter

It has already earlier become clear that microwaves play a fundamental role in living matter and I have performed a considerable amount of work in attempts to integrate various ideas to a coherent overall view. The ideas about dark matter hierarchy provide new insights to the problem although much remains to be understood.

6.7.1 Dark Microwaves And Metabolism

Already the model for plasmoids leads to the idea that microwave photons could serve as “food” of plasmoids. The basic objection that microwave photons have sub-thermal energies can be circumvented when microwave photons are dark.

Are dark microwaves produced in protein dynamics?

Micro-waves are produced by the protein conformational dynamics and the rotational transitions of water molecules and their clusters might mimic and amplify the rotational spectra of molecules. This could provide a first principle explanation for why one encounters microwaves in so many strange phenomena related to living matter.

In the most conservative approach, the internal degrees of freedom for atoms and molecules cannot be dark so that the conformational dynamics of proteins could not produce dark photons. It is however good to avoid too strong prejudices at this stage, and one can indeed imagine the existence of the dark counterparts of atoms and molecules having the same energy spectrum as ordinary atoms. One can also imagine what might be called N -atoms and N -molecules for which the spectrum of transition energies would be scaled up by a factor $N \leq r$, $r = 2^{k_d}$ and the emitted photons would have r -fold MEs as space-time correlates and could decay to bunches of N^k ordinary photons. Note that one has $h_{eff} = nh$, where n is product of distinct Fermat primes and power 2^{k_d} .

If this picture makes sense, the conformational and rotational dynamics of DNA and proteins could produce dark microwave photons at arbitrarily level of dark matter hierarchy. One can argue that the idea about N molecules literally on top of each other from the point of view of M^4 factor of embedding space looks rather strange. On the other hand, nothing strange is involved if one

looks the situation at space-time level. Here only the experiment can decide and the claims of Randell [D23] [D23] might be seen as an experimental support for the notion of N -atom in the case of hydrogen.

Dark microwaves as metabolic currency

If the intensity of the magnetic field is of about 2 Tesla, which by the quantization of magnetic flux corresponds to the p-adic length scale $L(157)$, (80 nanometers), electronic cyclotron transitions generate micro-waves and the system can thus generate its “food” itself. Also dark microwave photons can result in this manner.

Also the liberation of zero point kinetic energy in the dropping of protons and ions from $k = 151$ to larger space-time sheets generates micro-wave radiation and could be an essential part of the self-organization. In this case however the microwave photons would be ordinary photons and have sub-thermal energy. In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant h_{eff} so that cyclotron energy would be liberated.

The conformational and rotational dynamics of proteins provides a further mechanism producing microwaves and if the notions of inherently dark atom and molecule make sense this dynamics could produce metabolic energy utilizable by plasmoids.

Micro-wave MEs as bridges between space-time sheets

The earlier model for various phenomena discussed in this chapter emphasized the breaking of super-conductivity induced by a transfer of particles between super-conducting and non-super-conducting space-time sheets. In the recent framework the breaking of dark super-conductivity could occur by a phase transition to the ordinary phase. If the atoms and molecules are dark only in the sense they are ordinary particles topologically condensed on dark space-time sheets, their identity is not affected by the process. The mysterious appearance of atoms to places where they should exist is a signature of the phase transition. Sue Benford has documented this kind of phenomenon to be discussed later.

The transfer of charged particles between space-time sheets is possible provided flux tubes connecting the boundary of a smaller space-time sheet to the boundary of a larger space-time sheet are generated [K23, K24]. Particles simply flow along this bond connecting the space-time sheet to the larger space-time sheet, say magnetic flux tube, and also vice versa.

One can imagine various kinds of flux tubes and also MEs could act as bridges allowing particles to flow between different space-time sheets. In this case the acceleration of the charged particle in the electric field of ME gives it energy so that the mechanism could act also as a metabolic mechanism. In particular, MEs could drive protons from large space-time sheets to $k = 137$ space-time sheets by providing them with the energy of about 5 eV of metabolic energy quantum. Same applies to electrons.

The transfer could occur in several steps.

1. Quantum-classical correspondence suggests that it should be possible to understand how absorption of photons corresponds to the process in which the “bridges” are generated by MEs. MEs carry transversal electric field and magnetic fields. There is infinity variety of various kinds of MEs but for the simplest MEs electric and magnetic fields have constant linear direction orthogonal to each. Electric field defines a potential difference which is constant in length scales much shorter than the wave length of ME.
2. By generalizing the quantization of the magnetic flux to that for electric flux one obtains that the potential difference satisfies $eV = n\omega = nf \times 2\pi$. This means that an ion having a charge e accelerating in the radial field gets energy $E = n\omega$. Thus absorption of photon with energy $n\omega$ corresponds classically to acceleration in the electric field of ME and getting same energy. For ion having opposite charge acceleration would be replaced by deceleration and one must

speak of emission of photon with energy $E = n\omega$. The model for how ADP-ATP process is indeed based on the assumption that metabolic energy generates an electric potential in which protons are accelerated to get energy of .5 eV.

3. The proposed classical picture implies that ordinary micro-wave MEs can induce the transfer of ions to $k = 149$ and $k = 151$ space-time sheets and the transfer of electrons to $k = 157$ space-time sheets. The bridge generated by ME is expected to have a width given by atomic length scale. A good guess is that the thickness of MEs is given by the exotic weak length scale involved with the level of dark matter hierarchy in question.

6.7.2 Poorly Understood Effects Related To Micro-Waves

Micro-waves span the wave length range 1 mm–30 cm corresponding to the frequency range 300–1 GHz. There is support for the importance of micro-waves for living systems coming from various anomalous phenomena involving micro-waves. The connection with homeopathy has been already discussed and this discussion will not be repeated.

Microwave hearing

Micro-wave hearing [I96] is a phenomenon in which micro-waves in the frequency range 2-3 GHz (wave length range 150-10 cm) induce hearing sensation.

The basic features of the microwave hearing are following.

1. There is evidence that ears are not involved with the micro-wave hearing [I62]. The average pressure of the radar wave at the threshold of hearing is roughly three orders of magnitude less than the average pressure of a sine wave in air at the threshold of hearing air waves.
2. The location of the most sensitive area for hearing radar is remote from the ears, on top of the head.
3. The subjective frequency spectrum seems to include higher frequencies for radar hearing than for normal hearing of air waves.
4. The direction from which sound is experienced to arrive does not change as the head is turned around in the radar field.

For dark microwave photons the energies of photons would higher by a factor $r = 2^{k_d}$ and much above the thermal threshold which could explain the strong physiological effect.

Brain space-time sheet has correct size scale to serve as a receiving (dark) micro-wave antenna: it could also act as active radar generating (dark) microwave photons. That the most sensitive region is at the top of head, would conform with the assumption that dark microwave MEs modulated by audible frequencies induce the formation of plasma oscillations and these generate the sensation of hearing directly. This would suggest that the sensory input in ears could also generate microwave plasmoids as auditory mental images.

Microwave hearing allows to interpret the auditory hallucinations of schizophrenics as messages from various magnetic bodies, not necessarily the personal ones. Perhaps the immune system of schizophrenic fails to eliminate communications from non-personal magnetic bodies. Microwave hearing could also be involved with “God’s voice” which according to the theory of Jaynes was a key element of the bicameral consciousness [K105], [J85]. That micro-wave hearing could also explain the strange buzzing sounds reported by the witnesses of the Fatima apparitions, which served as a clue to the TGD based model of this phenomenon [K67].

Microwave static and taos hum

Micro-wave static is a strange phenomenon starting after sunset and ceasing after sunrise. It is known to be of biological origin. Taos hum [I127] is in turn a painful auditory experience resembling the sound of diesel engine having all physiological correlates of the ordinary hearing sensation although it has not been possible to detect the sound using microphones. The heard sound also reflects the geometric properties of the acoustic environment.

The interpretation in terms of microwave hearing suggests itself [K65]. Microwave static has a strong correlation with taos hum [I127]: taos hum begins and ends at same time. Physiological evidence suggests that microwave static can generate a response in the entire body of the patient. Perhaps the electromagnetic immune system of the patient is unable to censor out the microwave static.

Why taos hum? Could animals use microwaves for “seeing” in absence of sunlight? But for what purpose plants would use microwaves? Could organisms send negative energy $h_{eff} = n \times h$ [K36, K37, K38, K39] microwaves to environment and suck metabolic energy quanta with energy around .5 eV in this manner? Remote metabolism! Or maybe time reversed photosynthesis in dark! Biophotons indeed have energy spectrum in visible and UV as also sunlight does. This would require non-standard value of Planck constant.

This hypothesis would explain why the microwaves causing taos hum not hum are not observed directly. And if something is sucking metabolic energy from you, it is would be rather natural to experience very unpleasant feelings and try to find a place to hide as many sufferers of taos hum try to do!

Taos hum and quantum gravitation

I have been tormented from time to time by an unpleasant sensation of sound. Always at night. Last night it came back after a long time and lasted for several hours and I had to think about what it was.

During my stay here in Karkkila, it has been a very frequent night experience from time to time, especially in the summer. The sound source does not move. As if someone were keeping the car idling or even screaming the car engine to drive his fellow men to the brink of rage. It’s hard to think that anyone could continue this kind of bullying for very long. Even the option that someone would listen to, say, a video of formula race at night time year after year, seems unlikely already because of the reaction of the neighbors.

I had to think about these options too, because a few years ago my hometown was a victim of moped terrorists and speeders for a few summers until the police finally became active. Fortunately, that time has passed.

The option that the voices were hallucinations didn’t seem likely. Another option was that they are sensory memories. Such are possible and can be induced by electrically stimulating the temporal lobes. For example, some previously experienced pain due to some real cause can be chronically repeated as a sensory memory.

Then at night I realized a possible explanation. When I was living in Hanko, I wrote about a strange phenomenon called taos hum (taos hum) (see this). The TGD view of taos hum can be found at [K65, K58]. While writing the article, I realized that I had this syndrome myself!

1. An idling diesel engine is a good characterization for the sound. Here in Karkkila, the sound has been only more aggressive: as if deliberate gassing had been involved.
2. Taos hum is not detected by microphones and does not create a normal sensation of hearing. Taos hum cannot be connected to any device produced by technology. It starts after sunset and the initial cause seems to be biological. Interestingly, also animals and plants start producing electrostatic noise after sunset. In Karkkila, during the winter, there are no other options than trees.
3. Microwave hearing (Frey effect) could be involved. The series of microwave pulses can be modulated with low but audible frequencies, for example around 50 Hz. Microwave frequencies range is 3 decades: from 300 MHz to 300 GHz. They interact in the brain and produce an auditory experience. In which parts of the brain are not clear. The effect can also occur in the ears, but not in the normal way.

The carrier frequencies in the Frey effect are of the order of GHz. They are technologically significant (mobile phones for example) and this may explain why the effect has been reported for them. I am not aware of any reports regarding higher microwave frequencies that are not so technologically central. The piezoelectric effect, which converts electromagnetic radiation into sound and vice versa, could be essential to the effect.

Some people can sense the amplitude modulated frequency as a sound from radio masts, for example those used in radiotelephone connections.

Could it be taos hum, which I already picked up in Hanko! Funnily enough, once I realized this connection, I stopped hearing anything! As if someone had worked hard to force me to realize this connection!

Next, it occurred to me to guess the frequency for the carrier wave of the taos hum.

1. In quantum biology based on TGD, quantum gravity is essential and here Nottale's hypothesis is generalized and assigns macroscopic and even astrophysical quantum coherence to classical gravitational fields created by astrophysical objects.

In the Earth's gravitational field, the gravitational Compton wavelength is $\Lambda_{gr} = GM_E/\beta_0$, where the velocity parameter satisfies $\beta_0 = v_0/c < 1$. The corresponding frequency does not depend on the mass of the particle (Equivalence Principle). For $\beta_0 = 1$ one has $\Lambda_{gr} = .45$ cm. It corresponds to the microwave frequency $f_{gr} = 67$ GHz. This would be some kind of universal clock frequency of quantum biology.

2. I have considered also the possibility that computers [L148, L147, L156] could acquire some characteristics of a biological organism, if their clock frequency is higher than this frequency, because then the statistical determinism would no longer apply. In fact, the corresponding wavelength associated with the Sun is half the radius of the Earth and corresponds to the EEG frequency of 50 Hz, which inspires many questions.
3. For biomolecules, microwave frequencies play an essential role. Microwaves are associated with many strange effects such as ball lightning and light balls that have often been interpreted as UFOs. The creation of crop circles could be based on the same mechanisms as the explosion of a tomato in a microwave oven, which can be also used to produce this kind of light balls. There are also reports of lightballs in the act of building a crop circle.
4. Could the amplitude modulation of the radiation with gravitational Compton frequency produce the taos hum?! The modulating frequencies are in the EEG range and quite low (this brings in mind the gravitational magnetic body of the Sun). Why would this give the impression of an idling diesel engine? Could it correspond to some kind of random noise but what about the impression of deliberate gassing?

What comes to mind is a boxer who is in a state of maximal alertness ready to attack at any moment. This suggests a quantum critical state in which bursts of metabolic energy are randomly occurring. Note that the carrier frequencies would be microwave frequencies and by a factor of 67 higher than in the Frey effect, which has been associated with the microwave hearing.

There is also another important microwave frequency. The maximum for the frequency distribution of the cosmic microwave background is at the frequency 160 GHz and to wavelength .2 cm. This frequency is roughly twice the gravitational Compton frequency for Earth. This is close to the upper limit of microwave frequencies of 300 GHz. Is it a coincidence that these two frequencies are so near to each other?

Taos hum and stochastic resonance

Stochastic resonance [D20] [J57] occurs in the brain [D26] and its quantum analog serves as a candidate for the mechanism behind the perception of taos hum.

Consider first the classical variant of the stochastic resonance, which I have considered in [K98].

1. Classical stochastic resonance is an amplification mechanism for a signal represented as an amplitude modulation of a carrier wave with a basic frequency f and serves as a harmonic perturbation of a bistable system which is also subject to a white noise. In the recent case the message could correspond to the amplitude modulated signal with frequency f in the microwave range. $f = f_{gr}$ is an interesting option.

2. In the resonance, the signal frequency f must be one half of the average frequency $f(spont)$ for the jumps between two states of the bistable system: $f = f(spont)/2$. This condition has a simple physical interpretation: the height of the potential barrier separating the two potential wells varies periodically with a period which is half of the period defined by f , and the best opportunity to get to another potential well is to hop when the potential barrier is lowest possible.
3. For the mechanical analog system the rate $f(spont) = r_0 A$ is proportional to an “Arrhenius factor” $A = \exp(-\Delta V/D)$, where ΔV is the height of the potential barrier and D characterizes the intensity of the white noise. $f(spont)$ is also proportional to a factor $r_0 = \omega \omega_b / \gamma$ where ω is the frequency of small oscillations at either bottom of the symmetric potential well, ω_b is the analogous quantity at the top of the barrier (for harmonic oscillator potential one would have $\omega = \omega_b$), and γ characterizes the linear dissipative force (overcritical damping is assumed).
4. Thus, when the white noise has a correct intensity, a weak harmonic perturbation with a given frequency is amplified in the sense that the Fourier expansion of the system’s time development regarded as jumps between the two states contains a peak at the multiples of the frequency of the amplitude modulated harmonic perturbation. Neuroscientists refer to this phenomenon as phase locking. The peaks for the higher multiples of the input frequency f are exponentially suppressed. The notion of stochastic resonance makes sense also in the quantum context: now quantum tunnelling would replace the jumps induced by the stochastic noise.

Could stochastic resonance generalize to a quantum situation but with the ordinary ontology of quantum theory replaced with the zero energy ontology (ZEO)? What would be new is the identification of the ordinary quantum jump as “big” state function reduction (BSFR) in which the arrow of time changes. One can consider two interpretations.

1. Consider first the TGD analog of the standard interpretation. The jump between the potential wells corresponds to a quantum tunnelling as a transition of states with the same arrow of time and therefore involves two subsequent BSFRs. In stochastic resonance, the frequency $f(spont)$ for these tunnellings should satisfy $f = f_{spont}/2$. Each period $T = 1/f$ would correspond to two pairs of BSFRs. In the TGD framework, this interpretation looks too complicated.
2. For the second option, a single BSFR defines the counterpart for the hopping between two potential wells and 2 BSFRs define quantum tunnelling. Bistability has nothing to do with the details of the dynamics and is universal and corresponds to the two arrows of time. $f(spont)$ is identified as the rate for BSFRs rather than their pairs and characterizes external perturbations.

In the stochastic resonance, the rate $f(spont)/2$ for a pair of BSFRs would be equal to the carrier frequency f so that quantum tunnelling is in synchrony with the driving frequency f and each period corresponds to a quantum tunnelling. The intensity of the noise could be used to induce this synchrony.

This synchronization mechanism applies to all transitions and to all frequencies f but $f = f_{gr}$ would be in a special role since f_{gr} defines a universal gravitational Compton frequency. For instance, EEG could involve this mechanism and the halves of the EEG period would correspond to different arrows of time as I have indeed proposed in [K98] on basis of observations of brothers Fingelkurts [L18].

Tectonic lights and microwaves

Observations interpreted in terms of UFOs are often made near the lines of the tectonic activity and they could represent a life-form using the tectonic dark micro-wave photons energy as their “food” (quartz crystals generate micro-waves) and therefore following the micro-wave beam emanating from the spot of the tectonic activity. This would explain their random looking butterfly like

motion as being due to the random variation of the direction of the microwave beam. The decoherence of dark microwave photons to ordinary photons could in turn explain the observed but hard-to-understand luminous phenomena associated with tectonic lines.

6.7.3 X-Ray Images And Remote Realization Of Intentionality

M. Sue Benford has discovered rather fascinating and puzzling phenomenon in which some unidentified mechanism causes dots and tracks of size of order millimeter to X ray film [I162]. The interpretation in terms of tracks of ordinary charged particles is not possible. The intention of the experimenter or subject person seems to be strongly involved as well as a non-local information transfer. In particular, the emotional state affects the size of the dots. What makes these experiments so fascinating is that they dramatically differ from the ideal Cartesian experiment in which experimenter's mind does not affect the result of experiment in any manner.

These experiments provide support for the many-sheeted space-time concept of TGD and for a concrete remote realization of intentions as changes on X ray sensitive film by a mechanism involving micro-waves also associated with the conformational dynamics of bio-molecules such as proteins. The mechanism which basically involves a transfer of ions between atomic space-time sheets and super-conducting magnetic flux quanta, relates closely to the many-sheeted models of metabolism, quantum control of homeostasis, and molecular machines.

There is a close connection with other well-established anomalous phenomena such as taos hum and micro-wave hearing. The mechanism is involved also with the anomalous phenomena in the field of free energy [K131]. TGD predicts the possibility of plasmoidic life forms and dark microwave photons would serve as "food" of this life forms. This leads to a model of UFOs and UFO experiences: the model for Fatima Marian apparition witnessed by as many as 70.000 people was actually the key to the understanding of the role of micro-waves [K65]. The mechanism could also serve as a basic mechanism of psychokinesis and remote mental interactions [K97]. Also a remote information transfer might have been involved with the experiments. The sharing of mental images by quantum entanglement is a general TGD based mechanism making this possible [K97].

Holography type mechanism has been also suggested as a mechanism of remote mental interactions and is based on the idea that the fields generated by a living system form a representation for the system. In [I73] Benford has analyzed Dela Warr images [J41], and has shown that they possess hologram like aspects. There is indeed experimental evidence [?] that holography might be a basic representational mechanism allowing to represent information about body part in the radiation pattern generated by other body parts. The notion of conscious hologram discussed in [K21] allows to understand the hologram like aspects of DelaWarr images and the mechanism of bio-holography. As a matter fact, remote quantum entanglement and self-organization induced by the leakage of supra currents and/or by the reduction of charge entanglement induced by *W* MEs are basic aspects of conscious holograms. The holographic aspects are not considered in the sequel but the model to be discussed is consistent with the notion of conscious holography since the mechanism generating the X-ray images generates also conscious holograms.

I want to thank for M. Sue Benford for very enlightening and detailed discussions concerning axion experiments as well to as yet unpublished experiments in which intentional action induces similar effects on X-ray film. I am also grateful for Keith Fredericks for discussions related to his findings about tracks in nuclear emulsions which he interprets as evidence for tachyons [I144] and for Lian Sidorov for telling me about the work of Keith Fredericks.

A brief summary of the empirical findings

The effects of several mechanisms to the photosensitive emulsion (X ray dental film) were studied in the experiments. Part of the data are yet unpublished and in the following only the published data are discussed. In the case studied [I162] the so called axion generator developed by a Russian physicist Shpilman was used. The torsion field believed to be generated by the generator is in TGD framework replaced by Bose-Einstein condensate of dark photons associated with MEs. Exotic weak bosons and their dark variants induce long range parity breaking interactions possibly responsible for chiral selection in living matter.

The working hypothesis in [I162] was that the rotating axion generator generates so called axions, neutral pseudo-scalar elementary particles, which transform to X-rays in the presence of an

external magnetic field and might be detectable in the photosensitive emulsion. The spectrum of the electromagnetic radiation generated by axion generator was found to contain MHz portion and micro-waves in the range $.1 - 2.5$ GHz. Microwaves modulated by MHz waves are produced also by Priore's machine [I167], which suggests that the model of Priore's machine might apply almost as such also here. Interestingly, the micro-waves in the frequency range $.1 - 3$ GHz are known to be associated with the micro-wave hearing.

It was found that the film contained dots and tracks. According to the specialists, the dots and tracks could not be due to any known elementary particle traversing through the emulsion. What was strange that the sizes of the dots had sizes of order millimeter. This size is much larger than the typical sizes of dots. The size of the silver grains is below micro-meter [I144] and the number of grains along the track of a charged particle can be counted. This suggests that the interpretation in terms of an ordinary charged particle traversing the emulsion is not correct. What was also strange that the dots and tracks contained trace amounts of S, Mg and Al whereas the background region contained only C, N and O. Where did these elements come from?

In the case of charged particle very many X rays are emitted. The roughest estimate is one ionizing X ray per atom. In the case of axion only single X ray would result and it does not seem that the effect of single X ray could be so dramatic as to be much larger as the effect produced by very many X rays produced by a charged particle. Furthermore, if axion generates X rays it must have a mass measured in several electron volts. This does not conform with the cosmological bounds on axion mass (mass should be below 10^{-3} eV). Thus it would seem that the axion hypothesis is not supported by the experimental findings.

A further strange finding was that the intentional action of the experimenter affects the generation of dots and tracks and that there is a correlation with the emotional state of the experimenter and size of dots. The model for Priore's machine suggests that experimenter generated W MEs giving rise to plasmoids producing the tracks and dots, and that axion generator served as a source of metabolic energy in form of dark microwave photons.

The origin of the dots and tracks?

The model for the generation of dots and tracks is essentially same as that for the functioning of Priore's machine.

1. The role of axion generator could be analogous to that of Priore's machine: to produce dark microwave photons providing the energy needed to generate plasma wave oscillation quanta at microwave plasma frequencies making it possible to realize generalized motor actions using by generating plasma oscillation patterns.
2. In the present case the plasma oscillation patterns would be produced in the photographic emulsion. The reason why photographic emulsion can take the role of living matter could be that gelatin is one component of the X-ray emulsion. Gelatin consists of animal proteins and might have inherited some of the many-sheeted space-time structure of living matter making it possible to induce dark plasmoids provided the metabolic energy in form of dark microwave photons are present.

The generalized motor action by the magnetic body of the experimenter would now affect the emulsion instead of brain of the experimenter, where 1 mm sized neuron blobs could correspond to the seats of microwave plasmoids. This picture conforms with the fact that also mere intentional action can affect photographic emulsions. The correlation of the size of dots with emotional state would be understood if the intensity of classical W boson field (number of W bosons in BE condensate) and perhaps also the thickness of W ME correlates with the emotional state.

3. Dots and tracks can be generated intentionally, even within a very brief time interval measured in minutes. The size scale 1 mm for dots suggests interpretation as a p-adic length scale associated with scaled dark length scale $L(163 + k_d) = \sqrt{r}L(163)$, where $L(163) = .64 \mu\text{m}$ corresponds to the p-adic length scale assignable to Josephson radiation for ordinary value of Planck constant. The estimate for r is from this $r = 2^{k_d}$, $k_d = 21$. Using the previous formula for the dark energy of microwave photon this predicts for the energy of dark microwave photon with frequency $f = .1$ GHz $E = 8.6$ eV, which is somewhat too large. By

replacing 1 mm with .5 mm one obtains $E = 2.15$ eV consistent with the model of EEG. For much higher microwave frequencies energies are in UV and are not expected to couple to the cell membrane.

4. Dots and tracks contain S, Mg, Al which should not be there but they are in trace amounts. The phase transition transforming dark space-time sheets to ordinary ones involving possibly also the transformation of inherently dark S, Mg, and Al atoms to ordinary ones could explain this finding. Neither zero point kinetic energy nor atomic and molecular energies are changed in this process. The process involves the dissipation of the energy of plasmoid which could transform to UV photons and X rays by de-coherence.

The dependence of the dot size on emotional state of the experimenter supports the view that the experimenter is the intentional agent producing the dots and tracks. Neuronal columns with height and transversal size scale of order 1 mm are the basic information processing units in the cortex. This is consistent with the assumption that neuronal columns controlled from magnetic body by dark W MEs generating millimeter sized plasmoids via de-coherence. The control by highest levels of dark matter hierarchy could be of special importance in frontal lobes believed to be specialized to intentional actions.

Alternative model for dots and tracks

The original model for dots and tracks was based on the leakage of supra currents to atomic space-time sheets. If flux tubes connecting magnetic flux tubes to the atomic space-time sheets are formed in the millimeter sized regions then also super-conducting dark ions can leak to the atomic space-time sheets and transform to ordinary matter at the same time. The dots could have been caused by the ionizations caused by these super-conducting ions if they had sufficient energy.

Already the Nobel chemist Langmuir observed for 100 years ago effects with this interpretation when he was desperately to build vacuum tubes and realized that gas was flowing inside the tubes by an unknown [I72] [D32]. Crop circles [K41] are known to involve micro-wave explosions in growth nodes and the mysterious appearance of a layer of magnetized meteoric iron to the plants and soil proposed to involve currents from ionosphere. Leakage of dark ionic supra-currents from magnetic flux tubes explains the phenomenon and provides support for supra conductivity in astrophysical length scales [K41, K40].

The mechanism is involved also with the anomalous phenomena in the field of free energy and the recent experiments of Modanese and Podkletnov [H16] provide additional support for the leakage phenomenon [K131]. An interesting question is whether the dots and tracks in X-ray films disappear if the local magnetic field of Earth is artificially cancelled.

6.8 Activated Water, Homeopathy, And The Basic Mechanism Of Immunity

A considerable progress has occurred in the understanding of TGD inspired theory of consciousness and quantum biology during the first half of 2013. I have not however included separate sections about this progress since other chapters of “TGD Inspired theory of consciousness” (see <http://tinyurl.com/y726shp2>) already contain the relevant material. A detailed representation of the recent vision (see <http://tinyurl.com/yaq75hg6>) about TGD inspired theory of consciousness [K27] is recommended for the reader interested in details and various philosophical problems and their solutions in TGD framework. Also the chapter about the relationship between biophotons and dark photons (see <http://tinyurl.com/yanzr9xw>) [K17] is highly recommended.

The new picture allows also much better understanding of quantum biology. The work during the first half of 2013 has allowed to develop in detail several ideas about the role of the magnetic body. Magnetic flux tubes serve as correlates for the formation of quantum coherence and directed attention. The phase transitions changing the value of \hbar_{eff} leading to a change of flux tube length and the reconnections of the flux tubes play a key role in bio-catalysis. The dark photons propagating along MEs parallel to the flux tubes make possible resonant interactions between the entities at their ends and the proposed view about sensory, memory, and cognitive representations relies on hypothesis that the braiding of flux tubes defines negentropically entangled systems

representing information which is read consciously and non-destructively in good approximation by using interaction free quantum measurements. Dark photons transform to ordinary photons in energy conserving manner and bio-photons are identified as outcome of this process.

With this background one return to the old question “What is the exact mechanism of homeopathic healing?”. I have considered already earlier answers to this question but they have not been completely convincing. It turns out that one manages to add the missing piece to the puzzle by making the simple question “What is the molecular cause of illness and how homeopathic remedy eliminates it?”. Amusingly, I could have identified this piece for years ago but for some reason did not pose the correct question.

The resulting model of homeopathic healing is amazingly simple and at the same time a universal model of biocatalysis. The entity mimicking the invader molecules “steals” its cyclotron frequencies by varying the thickness of magnetic flux tube and thus magnetic field strength and cyclotron frequency until reconnection with the molecule’s magnetic body becomes possible and fusion to single quantum coherent system occurs. In TGD inspired theory of consciousness this process corresponds to directed attention and conscious recognition of the presence of the invader molecule. After this the mimicking entity freezes the thickness of the flux tubes in question becoming thus capable of mimicking the invader molecule and attach to the receptors of the invader molecule and steal the attention of the host organism and induce healing.

The results summarized in the book “Applied Biophysics of Activated Water” of Vysotskii *et al* [L17] provide a test bench for the proposal and allow to formulate it in a more detailed manner. The basic message of the book is that the activation process yields water with anomalous physical properties including water memory and having highly non-trivial - in general positive - effects on living matter. The identification of activated water as ordered water appearing in cell interior is proposed.

This and the general features of the activation process inspire the question whether the analog of the activation process might have taken place during pre-biotic evolution and generated ordered water making DNA stable. Molecular mimicry making possibly immune system would have emerged at the same step and meant also the emergence of symbolic representations. Also the pairs formed by receptor molecules and molecules attaching to them would have emerged at this crucial step when dark matter enters the game. One of they key questions is whether it is dark water molecule clusters or dark DNA that performs the mimicry of various molecules. The results of the book lend support for the model based on dark DNA.

6.8.1 Short Summary About “Applied Biophysics Of Activated Water” Of Vysostkii Et Al

“Applied Biophysics of Activated Water” (see <http://tinyurl.com/p8mb97n>) by Vysotskii *et al* [L17] gives a nice summary about the experiments carried out by using what they call activated water. One can say that the experiments provide a strong support for the notion of water memory. In the following I present a short summary about the contents of the book with associations to TGD inspired view about water memory and homeopathy.

The anomalies of the ordinary water

It is well-known that ordinary water is characterized by a large number of anomalies and the existing standard physics models can at best can provide parameterization of the findings but cannot really explain the anomalies. The tough challenge is to not only predict the physical properties (mechanical, electromagnetic, spectral) of water but also to understand the effects of the activation of water on these properties plus the effects of the activated water on living organisms.

The authors describe so called clathrate model introduced already by Pauling. The assumption is that water molecules form tetrahedron like structures having at its vertices dodecahedrons built out of water molecules. This clustering means that the system can be seen as a two phase system consisting of these clusters and “free water”.

The key challenge is to understand the relaxation times for various changes of water induced by say electromagnetic fields. The general order of magnitude for the relaxation of mechanical changes is given by so called Drude time, which is about 10^{-13} seconds according to quantum mechanics and thermodynamics. The duration for the changes induced by activation are measured

in days to that the discrepancy is 18 orders of magnitude: quite a challenge for a theoretician refusing to consider the possibility that biology and even the physics of water might involve new physics. An interesting observation is that in TGD framework the values of \hbar_{eff}/\hbar can have even order of magnitude of order 10^{18} . Note that the time period associated with photons with 2 eV energy is $.2 \times 10^{-14}$ seconds: this is by a factor 1/50 shorter than Drude time.

1. Could Drude time τ_D be scaled up like \hbar_{eff} ? This is not possible. Drude time is thermodynamical parameter: essentially the time $\tau_D = a/v_{th}$ taken for proton to move distance of order interatomic distance $a \sim 1$ Angstrom with thermal velocity $v = \sqrt{2T/m_p}$. Drude time does not depend on Planck constant so that the scaling $\hbar \rightarrow \hbar_{eff} = N\hbar$ does not affect τ_D . Some other time scale should characterize the stability and duration of the structures responsible for water memory. Moreover, these structures need not be made of ordinary water molecules. If so, dark protons - giving rise to what I have called dark DNA, RNA, ... - and their magnetic bodies define an a building brick of the needed structures. The earlier proposal inspired by anomalous stoichiometry of water in atto-second time scales indeed is that dark DNA sequences are formed in water.
2. An interesting observation relating to τ_D is that apart from a numerical factor of order one it happens to correspond to a photon energy of .041 eV, which is somewhat below the value of electrostatic energy associated with the membrane potential (and also the energy of thermal photon in physiological temperature). In TGD inspired biology cell membranes are Josephson junctions for electronic super-conductor and the model of high T_c superconductor predicts that the p-adic scaled up electronic Compton length $L_e(151) = 10$ nm defining cell membrane thickness are associated with both high T_c and bio-super-conductivity. The so called Josephson time defining the fundamental period of Josephson radiation given by $\tau_J = 1/f_J = \hbar_{eff}/ZeV$ and scales like \hbar_{eff} , and can therefore be very long. Also cyclotron times characterizing magnetic bodies are very long as compared to Drude time. Could these time scales replace Drude time?
3. Activated water is reported to contain polarized layered structures. The proposal is that activated water is actually ordered water appearing inside living cell. Living cell is filled by membrane like layered structures of thickness given by $L_e(151) = 10$ nm with voltage over the membrane given by membrane potential. Could the polarised layers of activated water be predecessors of cell membranes? Could Drude time be replaced with the fundamental period of Josephson radiation given by $\tau_J = 1/f_J = \hbar_{eff}/ZeV$ and by cyclotron times $\tau_c = 1/f_c$, $f_c = ZeB/2\pi m$ depending on charge and mass of charge superconducting object?
4. The electric field over cell membrane is very strong and one can argue that so strong an electric field cannot prevail in water. This might be the case. The problem could be however circumvented by assuming that the layers are thicker but have same voltage over them.

Basic notions related to water activation

In the second chapter authors discuss the basic conceptual framework behind water activation. They introduce the notions of fractalization, complementary, and the existence of a lattice like structure formed by membranes that act as barriers.

1. The notion of fractalization is rather easy to understand. Fractal growth reducing to a scaling of the overall size is basic example of this. The basic question concerns the mechanisms making possible fractal growth, and the replication of existing basic structures is a natural basic mechanism. For a layered structure this would mean the division of layer two two thinner layers, which then grow to the original size. This kind of mechanism might be at work also in the activation of water and in manufacture of a homeopathic remedy.
2. Complementary remained somewhat fuzzy notion to me. It is stated that it means minimization of contradictions: this brings to my mind Marxist philosophy and Hegelian dialectics. What comes in my mind are spin glass like systems characterized by large degeneracy of ground states with same energy. In TGD framework the vacuum degeneracy of Kähler action strongly suggests 4-D variant of spin glass degeneracy.

3. Biology is full of lattice like structures formed by membranes dividing the world into interior and external parts and serving as barriers. Cell membranes and endoplasmic reticulum (see <http://tinyurl.com/2bcktl>) [I16] inside cell are basic examples of this kind of structures.

MRET

MRET is a shorthand for Molecular Resonance Effect Technology used to activate water. Reader is encouraged to consult the book to get more detailed view about MRET.

1. Activation process involves irradiation of a cylinder containing polymer compound using optic pulses with frequency varying in ELF range 7-8 Hz arriving in vertical direction from above. One could also speak about slow modulation of visible light beam using ELF frequency. The cylinder contains transversal magnets generating magnetic fields inside the polymer compound. The vessel containing the water is below the cylinder.
2. The cylinder containing a complex polymer compound characterized by fractal volumetric matrix. This structure consists of linear polymers in parallel giving rise to lattice like structure. The polymers are liquid crystals and piezo-electrics transforming electromagnetic radiation to mechanical oscillations and vice versa. Epoxy (see <http://tinyurl.com/2o682n>) is mentioned as an example of a polymer used in activation.

There are three horizontal magnets inside the cylinder. The value of the magnetic field inside the polymer varies but is at most of order 100 Gauss. At distance of about 3 cm from the polymer the field in water has order of magnitude of 10 Gauss and is reduced rapidly with distance. In the approximation as a sum of three dipole fields created by horizontal magnets the field decreases as $1/r^3$ where r is the distance from the dipole approximating the three parallel horizontal magnets. In the first rough approximation the field lines of the magnetic field are horizontal in the water sample. In TGD framework the topological quantization of the magnetic fields is an important additional factor and could be highly relevant for understanding how the layered structure of the polymer is transferred to that of the activated water.

3. The structure of the polymeric compound is rather complex. The geometric structure is that of a fractal volumetric matrix - as authors state it. The structure contains nano-rings forming larger rings with 10 nm size scales and these in turn form larger rings. The sizes of the larger rings are reported to vary from 100 nm to 1000 nm. The polymer contains also various metal ions. The field patterns generated or modulated by this structure - in particular magnetic fields - should reflect the structure itself and could transfer some of it to the structure of the activated water.

6.8.2 Physical Effects Of Activation And Biological Effects Of Activated Water

Physical effects of the activation

The book reports the effects of the variation of various parameters on the properties of the activated water. Some variable parameters are the duration of the activation and the storage time. The general observation already mentioned and in blatant conflict with the quantum theory prediction is that the changes can last for days.

1. Long range correlations lasting for even days are induced in water. Layered structures consisting of polarized layers are generated with strong hydrogen bonding inside layers which have very weak mutual couplings. Mechanical, electrical, and spectral properties of water are affected. Viscosity can be anomalously low: this could be understood if the layer like structures having very weak coupling between them flow as almost independent units without mutual viscosity. Conductivity is reduced: for currents orthogonal to the layers this could be understood if charge carriers tend to be confined inside layers. Di-electric constant is modified at low frequencies. Long lasting pH oscillations of activated water are observed.

2. It is stated that the stoichiometry of water is affected but details are not given. It is mentioned that the effect on water is probably on protons of the water atoms and the lattice structure formed by them. It is stated that the effect of activation is also on proton spins and currents associated with hexagons of water molecules.
3. The activation process is known to generate ELF em fields with frequency spectrum in the range $[f_1, f_2] = [1 \text{ Hz}, 1 \text{ kHz}]$. The mechanism is not understood but the properties of the polymer compound must be partially responsible for this.

The biological effects of activated water

Most chapters of the book are devoted to the biological effects of the activated water. In general, the effects tend to be positive from the point of view of patient.

1. The effect of the activated water on plants - especially vegetables and crops - is studied. The activated water tends to promote their growth. One interesting finding is that activated water inhibits the growth of callus.
2. The effects on microbiological systems is investigated. The effect on cell cultures and cell cultures involving multifunctional symbiosis are studied. Both aerobic and anaerobic systems are considered. A general observation is that reductase activity grows. Reductase is an enzyme catalysing reductase (oxidation) reaction in which oxidation states of atoms are changed. Simple examples are oxidation of carbon to yield carbon dioxide and oxidation of glucose taking place in respiration. The effect of antibiotics is affected and can either increase or decrease. Bactericidal properties are enhanced: the growth of pathogenic cell cultures is inhibited, and the proposal is that activation could be used to sterilize water.
3. The effects of the activated water on prophylaxis (prevention of diseases) and on oncogenic diseases (cancer) are studied using animal models and cell cultures. It is found that the growth of certain kinds of tumours slows down and the life expectation increases. No negative side effects are found. There are also positive effects on immune system. The number of lymphocytes grows and the index characterizing cytotoxic activity increases. The dependence of effects in parameters like the duration of treatment by activated water and mode of treatment (before or after the incubation).
4. The effects of the activated water on staphylococcus infection are investigated in vivo using mice as an animal and in vitro using staphylococcus cell culture.

The general conclusion is that the treatment by activated water promotes healing, the anti-tumoral effect of lymphocytes with natural killing properties, and bactericidal properties. It inhibits the growth of tumor tissues, lengthens the life expectation of sick animals and prevents the growth of callus tissue. The conclusion is that activated water could have applications in both medicine, biology, biotechnology, and agriculture.

6.8.3 The Basic Ingredients Of TGD Inspired Model Of Water Memory

Magnetic body and the hierarchy of effective Planck constants characterizing dark matter

1. The notions of magnetic body and flux quantum - in particular flux tube carrying dark matter, and cyclotron frequencies whose collections serve as passwords are basic elements of TGD inspired quantum biology. The contraction of magnetic flux tubes in the phase transitions changing the value of \hbar_{eff} and therefore the length of flux tubes is the first basic process. Reconnection is second basic process allows the magnetic bodies to get in contact and rearrange so that the two distant systems can fuse to single macroscopic quantum system.
2. The formation of flux tube connection is interpreted as a geometric correlate for attention in TGD inspired theory of consciousness and the proposal is that consciousness is present already at the bio-molecular level - maybe even at elementary particle level. Reconnection is possible if local magnetic fields and therefore cyclotron frequencies of the two flux tubes are

identical so that resonance interaction by dark cyclotron photons follows as a consequence. The tuning of the local magnetic field by varying flux tube thickness would be an essential element in searching of molecules possibly present in environment. The finding of molecule would mean a generation of flux tube connection and resonant interaction and also consciously experience “sense of presence”. After this a shortening of the flux tubes by \hbar_{eff} reducing phase transition could take place and allow biomolecules or even more general entities to get in a contact allowing short range interactions such as chemical reactions. These would be the basic new physics elements in the TGD based description of bio-catalysis.

3. This picture allows also to understand the mechanism of water memory and homeopathy. Suppose that some structures in the water - perhaps water clusters with hydrogen bonds accompanied by flux tubes or dark DNA to be discussed - are able to vary the flux tube lengths of their dark magnetic body and in this manner consciously detect invader molecules. After having identified the invader they could freeze the length of the flux tube fixed and gain the ability to mimic the biologically essential aspects of the invader molecule coded by its cyclotron frequencies coded in turn by the field strengths constant along flux tubes in the first approximation (this is of course only a simplifying assumption). For instance, they can effectively replace invader molecules in organism in the sense that the receptors usually accepting the invader accept also the fake invaders meaning that invaders lose the attention of the host organism. This could be the basic mechanism of homeopathic healing. The cheating mechanism has many variants since also fake variants of the ordinary biomolecules are possible. Dark DNA actually could be seen as example of this kind of structure.
4. Hydrogen bonds are certainly one factor making water so special. A natural candidate for the flux tube performing mimicry would be a flux tube accompanying hydrogen bond and one could consider the possibility that dark flux tube corresponds to a dark hydrogen bond between dark protons.
5. The original model for the water memory and homeopathic healing was more complex. The idea was that water molecule clusters or dark DNA “steals” the magnetic body of the invader molecule. The idea was that ordered water forms an “ice” layer around the invader molecule and magnetic body of the invader molecule attaches to this. After that the magnetic body associated with the layer would be “stolen”. This is however un-necessarily complicated. For biological purposes (ability to reconnect with molecules able to reconnect with the invader) it is enough to steal/copy the cyclotron frequencies and the tuning mechanism makes this possible. The topologies and geometries of the two magnetic bodies can be quite different: only the identical values of local magnetic field is required.
6. One should keep mind open for a great variety of mimicries since dark magnetic body characterizes all ordinary matter systems, and the mechanism of attention making possible conscious recognition of other molecules and their subsequent mimicry is completely general. This would conform with the vision about Universe as a topological quantum computer and with the idea that the basic characteristic of a computer is ability to emulate, mimic. Note however that it requires $\hbar_{eff}/\hbar = N > 1$ and is not possible for ordinary matter: dark matter in TGD sense is required.

Negentropy Maximization Principle and dark matter hierarchy

In its recent form NMP [K73] is assumed to apply only in the rational intersection of the real and p-adic worlds, which for quantum states means that they are superpositions of pairs with identical entanglement probabilities $p = 1/N$. The number theoretic Shannon entropy indeed makes sense only in this intersection unless one identifies the integer valued p-based logarithm of p-adic norm as p-adic integer. For a generic entanglement one only requires that state function reduction gives rise to a measurement of the density matrix. This assumption implies that the final state is a maximally entangled system involving superposition of N states with identical and obviously rational entanglement probabilities $p = 1/N$.

According to the recent interpretation the hierarchy of effective Planck constants $\hbar_{eff} = N\hbar$ corresponds geometrically to N -furlcations for space-time sheets made possible by the failure

of the strict determinism of Kähler action and producing physically essentially identical copies of the system. The negentropic entanglement central in TGD inspired biology corresponds to entanglement of two systems of this kind with density matrix equal to $N \times N$ unit matrix (see **Fig. <http://tgdtheory.fi/appfigures/cat.jpg>** or **Fig. ??** in the appendix of this book). State function reduction as a measurement of density matrix can lead to this kind of density matrix stable under NMP. By NMP real-to-p-adic transitions giving rise to cognitive representations can take place only to p-adic sector for which the power of prime dividing N is largest among the prime power divisors and cognition is possible only for large for systems with $N > 1$ and therefore not for the ordinary matter.

Clearly, several ideas are unified: quantum criticality as a presence of N degenerate states realized by space-time sheets of N -furcation, negentropic entanglement, hierarchy of Planck constants, and the idea about life as something in the intersection of real and p-adic worlds ($p = 1/N$ is rational number). Furthermore, the measurement of density matrix automatically leads to exact criticality. In dynamics without state function reduction criticality is approached only asymptotically. Note that in self-organized criticality [B2] the criticality corresponds to a minimum of potential with some flat directions in which the situation is non-deterministic at criticality.

How Akashic records are read?

The recent view about TGD inspired theory of consciousness [K27] involves besides dark magnetic bodies also dark photons. Dark photons have $\hbar_{eff}/\hbar = n > 1$. The model for sensory, memory and cognitive representation as a realization of the reflective level of consciousness identifies these representations as approximate invariants of quantum jump sequence formed by negentropically entanglement systems defining kind of Akashic records. The approximate invariance is guaranteed by NMP. In ZEO quantum jumps can occur at both boundaries of CD and can add additional tensor factors to the negentropically entangled system representing “Akashic records”.

How could one read “Akashic records”? The original conjecture was that the so called interaction free measurement (see <http://tinyurl.com/y9zenssv>) could make this possible.

1. Interaction free measurement has been described in a concrete manner as a method to determine whether bomb is dud or active. There are four detectors at corners of a square abcd. The mirrors at a and d reflect and transmit. The mirrors at b and c only reflect. There are two detectors C and D at d and one can arrange that for a superposition of photon paths a destructive interference occurs at C (no firing) whereas D fires. If one has only path acd either C or D fires. For path abd bomb explodes as photon is absorbed.
2. Active bomb at path ab acts as an ordinary measurement apparatus and reduces a superposition of two photon paths abd and acd to either of them. If the resulting path traverses detector (abd), an explosion occurs. Otherwise (acd) not. Dud cannot absorb the photon - it cannot act as a detector - and leaves the superposition of photon paths unaffected. If C fires, one can conclude that the bomb was active. If bomb is dud D fires. Otherwise one cannot be certain. One can optimize the measurement so that ideally no explosions occur and all active bombs are detected.

What is important that ordinary state function reduction occurs for the superposition of photon paths also in the interaction free measurement. What is deduced from the interaction free measurement is whether bomb can act as ordinary measurement instrument (active) or not (dud). In particular, one cannot determine entanglement without reducing it, as I erratically assumed first.

The bomb serves as a metaphor for a two-state system with photons exciting the higher energy state provides the system. Higher energy state corresponds to the dud and lower energy state to active bomb.

3. I have given up the idea about interaction free measurement as a way to determine what negentropic entanglement is. In the recent formulation of TGD inspired theory of consciousness one can and must assume that the reading of the “Akashic records” is a key aspect of conscious experience. In Zero Energy Ontology the negentropic entanglement is associated with the boundary of causal diamond (CD) not affected in the sequence of state function

reductions leaving that state at it (Zeno effect) unchanged whereas the state at opposite boundary changes as also the position of the opposite boundary, whose distance from the lower one increases reduction by reduction: this gives rise to the experienced flow of time. The changing boundary contributes to the conscious experience sensory input and everything induced by it - “Maya”. The un-changing boundary corresponds to experience about having unchanging self.

Dark DNA

I ended originally to the notion of dark DNA by what looks a pure accident. I considered a model for what dark proton (or nucleon) could be, and had in mind that nucleus would be a string of dark nucleons as a generalization of nuclear string model [L3] developed already earlier. The surprising finding was that the states of dark proton in the simple model correspond in a natural manner to DNA, RNA, tRNA, and amino-acids: in case of tRNA the number of states is predicted to be smaller than 64. Even more, vertebrate genetic code as an assignment of DNA codons to amino-acids followed from simple assumptions. This raised the question whether genetic code and the counterparts of biomolecules could be realized already at the level of dark nuclear physics as sequences of dark protons or neutrons or both. If this were the case, then biological life could be seen as a kind of chemical emulation of the life at this more fundamental level.

The natural question is whether the dark variants of biomolecules can be transformed to their ordinary counterparts and vice versa by processes analogous to transcription and translation. If so, one can consider a possibility of R&D department of biology performing experimentation with dark variants of biomolecules. The biological evolution in this framework would not be due to a random mutations followed by selection performed by environment but a guided and controlled process analogous to what happens in the evolution of technology. Basically the question is about whether the Nature so silly that it decides to develop a highly refined technological product such as computer by throwing some silicon and metals to jungle and patiently waiting for them to self-organize to a computer.

The basic unit of dark DNA would be proton. The states of single dark proton would corresponds to DNA, RNA, ..etc. One can imagine dark DNA double strands and the finding Hu and Wu [J82] that proton pairs with distance of 10 nm associated with opposite lipid layers of cell membrane correspond to an analog of cyclotron frequency in EEG range, suggest that the pairs of protons located at opposite sides of cell membrane give rise to dark DNA double strands. The protons would be connected by a “short” flux tube and also a “long flux” tube outside the structure is needed to obtain closed flux lines: this could be of course avoided by assuming wormhole flux tube consisting of parallel flux tube space-time sheets extremely near to each other and having same M^4 projection and carrying opposite fluxes. If the “long” portion of the flux tube is present as assumed in the model of “Akashic records”, it carries the cyclotron Bose-Einstein condensate allowing to consciously read the records realized in terms of the braiding of the short portions of flux tubes. This is certainly not the only possible option. The flux tube portions connecting dark protons to ordinary DNA could also carry the braiding serving as a correlate for the negentropic entanglement. This alternative conforms with the vision about DNA as topological quantum computer [K3].

The stability of the highly charged sequence of dark proton pairs is of course a problem. The lipids could carry the stabilizing charge: phosphates serving as the energy carrying part of ATP are in general negatively charged and this could stabilize the system formed in this manner. Note that also DNA double strand is negatively charged due to the presence of phosphates: the stability is in fact a challenge for a theoretician. One possibility is that dark protons with large value of Planck constant participate in the stabilization of the double strand.

The anomalous stoichiometry of water at atto-second time scale could be due to the formation of dark sequences of protons. Suppose that the manufacturing of the homeopathic remedy produces ordered water having layered structure and that these layers are analogous to cell membranes and that double dark DNA strands are formed at the both sides of the layer. Coulombic stability is an important factor. For arrangement of type NP-NP-NP... the oppositely charged neighboring outer surfaces of the layers would stabilize the system. For PN-NP double layer the stabilization might be due to the presence of dark protons attached to the two outer surface of type N. In this case one would have a system analogous to two lipid layers. Note that also negative

charges, presumably electrons would be required to stabilize the system.

If one takes homeopathy seriously, one can deduce an argument favoring not only dark DNA but requiring also its evolution: this argument will be discussed later. The basic problem is that continual dilution of the water in the preparation of the homeopathic remedy leads also to an extremely low density of the entities able to mimic the magnetic body of the molecules initially present. This is true also for dark DNA unless dark DNA is able to replicate or at least transcribe to dark RNA in turn transcribing to dark DNA. The replication mechanism could be similar to that of ordinary DNA and rely on the reconnection of flux tubes.

Brain metabolic DNA as an indication for genomic R&D based on dark DNA

I learned a lot in SSE-2016 conference. For instance, the notion of brain metabolic DNA (BMD) about which Antonio Giudetta had a nice poster was a new notion to me. TGD suggests active R&D like process driving genetic evolution and I have been a little bit disappointed since epigenetics is too passive in this respect. BMD would fit with my crazy speculations.

I try to summarize my first impressions about brain metabolic DNA.

1. The profiles for both the repetitive and non-repetitive fractions differ from native DNA and for learning rats differs from those for control rats. Stress and learning situations induce this process and it occurs at least in brain.
2. Wikipedia lists DNA replication and repair as the basic mechanisms of DNA synthesis. They would yield essentially a copy of native DNA. Does this mean that there could be some new mechanism responsible for the synthesis?

I have worked with two new new mechanisms of DNA synthesis emerging from TGD based new biophysics for which MB consisting of magnetic flux tubes carrying dark matter identified as large $h_{eff} = n \times h$, n integer, phases is crucial.

These new phases of ordinary particles identifiable as dark matter would make possible macroscopic quantum coherence in much longer length scales than usually for large values of n since Compton length is proportional to h_{eff} . Large h_{eff} would make living matter a macroscopic quantum system. Large h_{eff} phases would be created at quantum criticality: the large values of Compton lengths would be correlates for long range correlations and quantum fluctuations. Quantum criticality is indeed emerging as a basic aspect of living matter.

1. The experiments of Montagnier *et al* [I103] [L11] suggest that remote replication of DNA involving sending information about the template strand using light is possible. Peter Gariaev's group has made similar claims much earlier. Together with Peter Gariaev we published an article in Huping Hu's journal DNADJ about remote replication of DNA before the work of Montagnier [K149] (see <http://tinyurl.com/gnj5bxh>).

The idea is that what I call dark photons (see below) carry genetic information. Dark photons would have energies in visible and UV range and could transform to biophotons with same energy. This would make them bio-active since biomolecules have transition energy spectrum in this range. The challenge is to understand the details of the information transfer mechanism. What would be needed would be regeneration DNA or dark DNA at the receiver end using the information. How this precisely occurs is of course only a subject of speculation.

This mechanism as such would not however apply to this situation since the ordinary DNA could not serve as template.

2. The notion of dark DNA is one of the key new physics notions of TGD and the transcription of dark DNA to ordinary DNA could be involved with generation BMD.
 - (a) The proposal is that genetic code has realization at the level of "dark" nuclear physics [L34] (see <http://tinyurl.com/jgfy1be>). Dark DNA would correspond to dark proton sequences having interpretation as dark nuclei. Darkness would mean that the protons are in phase with non-standard value of Planck constant given by $h_{eff} = n \times h$, n integer which can vary. The value of h_{eff} learns as a kind of intelligence quotient since

it tells the scales of long term memory and intentional action and also the size scale of the system). It could serve as intelligence quotient of cells and pyramidal neurons generating EEG as Josephson radiation (frequency of Josephson radiation is $f = 2eV/h_{eff}$ in terms of membrane potential V) could be the neuronal intellectuals).

- (b) Dark DNA could accompany ordinary DNA as parallel dark proton strands. The negative phosphate charge would neutralize the positive charge of dark protons so that the system would be classically stable. The ability to pair in this manner would quite generally select preferred biomolecules as winners in evolution.
- (c) For instance, the transcription of dark DNA to ordinary DNA is possible: dark DNA would serve as template for the ordinary DNA codons. Dark variants of biomolecules could make possible R&D in living matter. Evolution would not be by random mutations plus selection but intentional and more analogous to occurring in R&D laboratories.
- (d) If dark DNA strands were used as templates in the generation of BMD one could understand why learning BMD differs from the native DNA. Primarily the dark DNA would be modified as a response to learning and the modification would be transcribed to that of ordinary DNA.

The interesting question is whether these changes could also be transferred to the germ cells say by sending the information in form of light and generating copies of newly generated DNA portions replacing the original ones.

Is dark DNA dark also in TGD sense?

I encountered a highly interesting article about “dark DNA” hitherto found in the genome of gerbils and birds, for instance in the genome of the sand rat living in deserts (see <http://tinyurl.com/y8zdgnej>). The gene called Pdxl related to the production of insulin seems to be missing as also 87 other genes surrounding it! What makes this so strange that the animal cannot survive without these genes! Products that the instructions from the missing genes would create are however detected!

According to the ordinary genetic, these genes cannot be missing but should be hidden, hence the attribute “dark” in analogy with dark matter. The dark genes contain A lot of G and C molecules and this kind of genes are not easy to detect: this might explain why the genes remain undetected.

A further interesting observation is that one part of the sand rat genome has many more mutations than found in other rodent genomes and is also GC rich. Could the mutated genes do the job of the original genes? Missing DNA are found in birds too. For instance, the gene for leptin - a hormone regulating energy balance - seems to be missing.

The finding is extremely interesting from TGD view point, where dark DNA has very concrete meaning. Dark matter at magnetic flux tubes is what makes matter living in TGD Universe. Dark variants of particles have non-standard value $h_{eff} = n \times h$ of Planck constant making possible macroscopic quantum coherence among other things. Dark matter would serve as template for ordinary matter in living systems and biochemistry could be kind of shadow of the dynamics of dark matter. What I call dark DNA would correspond to dark analogs of atomic nuclei realized as dark proton sequences with entangled proton triplet representing DNA codon. The model predicts correctly the numbers of DNA codons coding for given amino-acid in the case of vertebrate genetic code and therefore I am forced to take it very seriously [L34, L30] (see <http://tinyurl.com/jgfy1be> and <http://tinyurl.com/ydb2tfy8>).

The chemical DNA strands would be attached to parallel dark DNA strands and the chemical representation would not be always perfect: this could explain variations of DNA. This picture inspires also the proposal that evolution is not a passive process occurring via random mutations with survivors selected by the evolutionary pressures. Rather, living system would have R&D lab as one particular department. Various variants of DNA would be tested by transcribing dark DNA to ordinary mRNA in turn translated to amino-acids to see whether the outcome survives. This experimentation might be possible in much shorter time scale than that based on random mutations. Also immune system, which is rapidly changing, could involve this kind of R&D lab.

Also dark mRNA and amino-acids could be present but dark DNA is the fundamental information carrying unit and it would be natural to transcribe it to ordinary mRNA. Of course, also dark mRNA could be produced and translated to amino-acids and even dark amino-acids could be transformed to ordinary ones. This would however require additional machinery.

What is remarkable is that the missing DNA is indeed associated with DNA sequences with exceptionally high mutation rate. Maybe R&D lab is there! If so, the dark DNA would be dark also in TGD sense! Why GC richness should relate to this, is an interesting question.

What replication could mean?

One can consider several meanings for replication central for living system.

1. Clays have been proposed by Cairns-Smith (see <http://tinyurl.com/y8wfyha4> [I56]) as a candidate for predecessors of life. The reason is that silicon which is the building brick of clay minerals has a chemistry similar to that of carbon and allows very rich repertoire of polymers. The division of clay layer to two layers growing after that to the original size could be seen as very simple replication mechanism. Similar mechanism might apply in ordered/activated water containing water layers.
2. The replication of dark DNA has been already mentioned. It could be analogous to a production of dark RNA in which only second strand serves as a template or genuine replication in which both strands replicate. The description would be in terms of reconnection the dark protons having flux loops come between the two dark DNA strands and reconnect with the flux tubes connecting the dark protons of strands. At the same time the analogs of valence bonds in longitudinal direction giving rise to dark nucleus as nuclear string emerge. After this a de-reconnection takes place and one obtains the analog of RNA strand besides the original DNA. A more complex process involves the same process for both strands and corresponds to DNA replication.

Note that the intensity of the flux associated with flux tubes must be same for all dark DNAs coding same dark amino-acid and for dark DNA coding corresponding RNA. Therefore dark variants of fundamental biomolecules correspond to frequencies. If also ordinary biomolecules are coded by same frequencies, the analogs of transcription and translation processes between ordinary and dark variants of biomolecule become possible by reconnection-contraction mechanism.

As noticed, the replication of dark DNA could induce the replication of corresponding layer, say, by inducing Coulomb instability.

6.8.4 TGD Inspired Model For Homeopathy

Does homeopathic remedy mimicking the pathogenic molecules prevent the chemical reaction causing the illness?

After a work of more than decade after the realisation that homeopathy might be understood in TGD Universe, I still find that I have not given an absolutely convincing answer to the question “What is the exact mechanism of homeopathy?”. The basic rules is that “like cures alike”. Why should this be the case? Let us go our arguments through once again.

1. Certainly the imprinting of water using molecules causing the illness - call these molecules just I for brevity - must be an essential part of the healing mechanism. The imprinting means imprinting of water with some frequencies in the low frequency spectrum of I . The TGD inspired idea is that the magnetic body of appropriate water cluster or even dark nucleon sequence representing DNA sequence, call this entity I^* , is able to mimic I in the sense that its cyclotron frequency spectrum is same.
2. This in turn strongly suggests that the molecules in the organism to be healed - call them P - have a long range interaction with molecules I induced by dark photons with cyclotron frequencies but having energies above thermal threshold. The interaction involves a formation of a magnetic flux tube accompanied by a parallel topological light ray/“massless

extremal" (ME) along which dark photons at specific resonance frequencies propagate and induce resonant interaction between P and I . Thus both the formation of flux tube bridge and the resonant interaction made possible by it, would be essential for the homeopathic healing to take place. In fact, in TGD inspired theory of consciousness [K27], the formation of resonating flux tube connections makes possible the quantum coherence for the combined system $I + P$ and serves as a correlate for attention between I and P .

3. The presence of the entities I^* able to mimic the cyclotron frequency spectrum of I and forming resonant flux tube bonds with molecules H is however not enough to explain the healing effect (I have already considered some answers but they do not convince me). To understand this, one must be able to understand how I causes the illness. The answer of the standard medicine is that the mechanism is chemical and thus requires contact interaction between I and P . It is easy to believe this. Standard medicine also tells that in order to prevent the chemical interaction between I and P , one must use some medicine molecules M , preventing this chemical interaction. It is easy to believe also this.

In TGD Universe there is indeed a very natural mechanism preventing the chemical interaction between I and P . The reduction of the value of the effective Planck constant associated with the flux tubes connecting I and P leads to a contraction of the flux tube length (proportional to \hbar_{eff}). This indeed makes possible a chemical contact interaction between both I and P causing the illness. In fact, I have proposed this mechanism as a completely general mechanism of catalyst action allowing biomolecules to find each other in the dense bio-molecular soup. But this holds true also for I^* and P ! Using terms of "molecular psychology", the entities I^* mimicking I steal the attention of molecules P so that molecules I cannot cause the illness anymore!

This indeed looks extremely simple and natural and thus also convincing. What is important is that the proposed mechanism is not in conflict with standard medicine: it only makes possible the miracles of bio-chemistry and provides a completely new mechanism of healing. It is easy to imagine that a new kind of medicine using only water imprinted by the cyclotron frequency spectra of molecules responsible for the illness. This medicine would be completely free of the negative -basically chemical - side effects of the ordinary drugs. This mechanism would also use all the knowledge gained by ordinary biochemistry based medicine: if the relevant molecule I is known, it can be used to imprint water to get I^* .

Also the effect of vaccines could rely on the "like cures alike" mechanism albeit in different form. Now the molecules or organisms - call them just B - causing the disease would be injected directly into the body rather than water. Water memory could give rise to a mimicry of B : s and give rise to primitive immunity. A more refined mechanism proposed earlier would involve dark DNA mimicking B : s and translating to ordinary DNA sequences coding for proteins able to catch B : s by the same flux tube mechanism.

The proposed mechanism of homeopathic healing leaves open the exact mechanism behind the cyclotron mimicry. The entities I^* could be water clusters with magnetic bodies mimicking those of I , they could be water clusters which have stolen the magnetic bodies of I , or they could be even dark DNA accompanying water molecules and able to mimic I . Of course, the least science fictive option is that the possibly existing dark DNA couples only with ordinary DNA by the flux tube mechanism.

Above I have defined illness as something caused by the detrimental chemical activities induced by invader molecules attaching to the receptors at cell membranes. This definition is too restrictive since it excludes genetic diseases. In this case, the removal of the cause of disease requires genetic engineering. If the universal reconnect-and-contract mechanism makes is possible to transcribe dark DNA to DNA, a new kind of genetic engineering can be imagined since the dark variants of biomolecules connected by flux tubes to cell interior could leak through the cell membrane serving as a barrier for larger biomolecules. A mechanism replacing a portion or damaged DNA with an undamaged one would be needed besides reconnect-and-contract mechanism. Also this mechanism could use reconnect-and-contract as a basic building brick it is easy to see by considering single DNA nucleotide as a simplified example. These mechanisms would also transform evolution by random mutations in presence of environmental pressures to a guided and controlled process involving experimentation with dark DNA defining kind of virtual DNA.

A slight-modification of this mechanism would transform damaged DNA portion to intron and add near it the transcription of dark DNA as exon. To transform exons to introns one must understand the distinction between them. TGD inspired proposal is that exons carry an electric field parallel to them whereas for introns there is no electric field. The control of this field - perhaps by manipulating electric charges generating it - is what comes in mind.

The interpretation of bio-photons as decay products of dark photons in energy conserving phase transition $\hbar_{eff} \rightarrow \hbar$ [K17] suggests that the dark photons involved with the communications have rather large value of \hbar_{eff} given by $\hbar_{eff} = f_h/f_l$. The simplest working hypothesis is that dark photons have same energy spectrum as bio-photons. The prediction would be that bio-photon spectrum from a homeopathic remedy - in particular its fluctuations - should correlate with the spectrum of the cyclotron frequencies. A weaker hypothesis is that the energies of dark photons are above thermal energy at physiological temperature.

What is the role of agitation in the preparation of the homeopathic remedy?

What could then be the role of agitation in the manufacture of the homeopathic remedy?

1. The mechanical agitation accompanying dilution could feed the energy forcing the replication of dark DNA. This process could be accompanied by the division of water layer to which dark DNA double strand is associated to two layers which eventually grow to the original size. Clearly, the division of the water layer involving replication of dark DNA would be the analog for cell division.
2. Could the mechanical agitation serve as an “environmental catastrophe” driving the evolution of dark DNA (and possible other dark variants of biomolecules evolving in the process). Could this evolution correspond to a gradual increase of \hbar_{eff} ? This can be the case if the dark photons involved can have also sub-thermal energies. In this case the evolution would mean increase of the energy of dark protons so that it would be eventually that of ordinary visible photons. The proposal that amplitude modulation produces dark photons would however suggest that the value of \hbar_{eff} is large from beginning.

Of course, it is also possible that energy conserving transformations of dark photons to dark photons $\hbar_{eff} = N_1 \hbar$ such that N_1 divides N are possible. One must be very cautious in making strong conclusions since the value of N for dark photons is very large and need not be identical for that for dark protons for which $\hbar_{eff} = N_p \hbar$ is expected to be roughly the ratio of cell membrane thickness to Compton length of ordinary proton and much smaller. It could well be that N_p is relatively small factor of N .

3. There is an interesting connection with Mersenne primes. The integers $P_n = (2^n - 1)2^{n-1}$, where $M_n = 2^n - 1$ Mersenne prime, are known as perfect numbers which by definition are sums of their proper divisors: the number $P_3 = 28 = 1 + 2 + 4 + 7 + 14$ is an example. P_n contains very large number of divisors as is clear from the presence of a power of 2. Also Mersenne prime itself divides perfect number. Hence, if one wants to produce a dark system with very large number of different values of Planck constant, $N = P_n$ is the proper choice. The number of divisors proportional to power of 2 is large also for the modulus of the analog of perfect number associated with Gaussian Mersenne.

What is especially interesting from the point of view of p-adic length scale hypothesis is that the values of Planck constant 2^k up to $k = n - 1$ are obtained. For $M_7 = 127$ powers of 2 up to $2^6 = 64$ are obtained and this might relate to genetic code. For M_{127} powers up to 2^{126} are obtained: this Mersenne corresponds to the proposed memetic code [K56].

Mersenne primes are the most important p-adic primes in TGD framework and label various scaled variants of hadron physics, weak gauge bosons, as also electron and tau lepton. Muon is labelled by Gaussian Mersenne. Could it be that Mersenne primes are favored because they give rise to maximally complex dark matter systems giving rise to cognition?

6.8.5 TGD Based View About The Activation Of Water

There are several questions to be answered if one wants to understand what happens in the activation of water and the properties and effects of the activated water. Could the model for water

memory and homeopathy apply to water activation and to the biological effects of the activated water? Could the water produced in homeopathic process be actually activated water (this should be easily testable)? Could the observations allow a more detailed model of homeopathy? Could the emergence of ordered water inside cell interior stabilizing DNA be understood as a process in which the environment manages to mimic the activation process and activates ordinary water. In the following these questions are considered in TGD framework.

The basic TGD based claims about activation process inspired by previous considerations are following.

1. Amplitude modulation produces dark photons and magnetic flux tubes containing dark particles and having at their ends dark protons. The emerging values of $N_i = \hbar_{eff}/\hbar$ are factors of corresponding integer defined by the ratio of modulated and modulating frequencies which should be integers with maximal number of factors to obtain optimal situation. Perfect numbers associated with Mersenne primes are optimal in this respect. Also the analogs of perfect numbers defined as moduli of $P_{G,n} = ((1+i)^n - 1)(1+i)^{n-1}$ for Gaussian Mersennes $M_{G,n} = (1+i)^n - 1$ could be optimal choice since the modulus is proportional to $2^{(n-1)/2}$.
2. Activation produces ordered water with layered structure and dark DNA strands consisting of sequences of dark protons at opposite sides of the layer are formed. The flux tubes associated with them can have varying thickness and this makes possible conscious recognition (at level of dark DNA) of the external molecules via reconnection process and copying its cyclotron frequency. This in turn makes it possible for the molecule to mimic the invader molecule and attach to the same receptors as invader. This would be a fundamental biochemical process involving conscious experience and also intelligence!
3. The electrolysis of water and also cavitation produces what is known as Brown's gas which should consist of water vapour. The properties of Brown's gas [H11] however do not support this interpretation: for instance, Brown's gas has temperature of about 130 C but is able to melt metals so that some un-known mechanism liberating energy must be involved explaining also the claims about over-unity energy production in water splitting using electrolysis. TGD inspired model for Brown's gas [K63] suggests that activated water and Brown's gas correspond to same phase involving polymer sequences formed from exotic water molecules for which one hydrogen nucleus is dark and defining the analogs of basic biopolymers. The bond binding protons to a polymer like sequence would serve as the counterpart of covalent bond.

One also ends up with a more detailed TGD inspired view about basic mechanism of metabolism in living matter predicting a tight correlation between p-adic length scale hypothesis and hierarchy of Planck constants. The model differs in some aspects from the rough models considered hitherto assuming that metabolic energy is liberated as zero point kinetic energy when particle drops to a larger space-time sheet or as cyclotron energy when cyclotron quantum number decreases. Now a phase transition increasing the p-adic length scale of the space-time surface would liberate either kinetic energy of cyclotron energy. Quantum numbers would not change: rather, the scale appearing as a parameter in the expression of kinetic or cyclotron energy would change adiabatically and in this manner guarantee coherence. Also a phase transition in which the changes of scale due to a reduction of Planck constant and increase of the p-adic length scale compensate each other liberate metabolic energy.

Does the activation process generate dark photons?

As explained, the activation process involves irradiation of the polymer cylinder in vertical direction from above using optic pulses with frequency varying in ELF range 7-8 Hz in the arrangement described. One could also speak about slow modulation of visible light beam using ELF frequency.

I have proposed this kind of modulation process as a way to produce dark photons with large value of \hbar_{eff} given by $\hbar_{eff}/\hbar = N = f_h/f_l$ where f_h and f_l are the high and low frequency respectively. I have also proposed that the process transforming high frequency ordinary photons to ordinary photons with the same energy could be essential also for the imprinting of water by certain frequencies [J28]. Gariaev's finding about transformation of visible light to radio-waves

could also take place via this process: now DNA would produce the low frequency radio-wave modulation modulating visible light beam and in this manner produce dark radio photons having biological effects. Biophotons would result in the reversal of this transformation for large \hbar_{eff} photons. There is experimental evidence for a correlation between fluctuations of EEG spectra and bio-photon spectra so that EEG photons would represent one example of dark photons [K17, K26].

The frequency band for ELF frequencies contains Schumann resonance $f_S \simeq 7.8$ Hz. This might not be an accident. In TGD inspired theory of consciousness self hierarchy is a basic prediction and “Mother Gaia” as a higher level in the self hierarchy corresponds to the Earth’s topologically quantized magnetic field. The flux quanta of personal magnetic bodies would reside inside the magnetic flux quanta of Mother Gaia and this would give rise to interaction between Mother Gaia and individual conscious entities.

Besides the Earth’s magnetic field also the magnetic field created by the magnets inside polymer is present in the water sample and a good guess it has a crucial role in water activation. These flux quanta need not however correspond to the flux tubes responsible for the water memory. Rather, flux sheets could be in question and they could define templates for the layers of the ordered water.

The polymer compound has fractal layer structure and contains nano-rings, rings or rings with size 10 nm, and rings made of these having sizes in the range 100-1000 nm. This length scale hierarchy brings in mind the existence of as many as 4 Gaussian Mersenne primes $M_{G,n} = (1 + i)^n - 1$, $n = 151, 157, 163, 167$ with corresponding p-adically scaled up electron Compton lengths in the range $L_e(151) = 10$ nm - $L_e(167) = 2.5$ μ m. $L_e(151)$ corresponds to cell membrane thickness and also to the thickness of the coil formed by DNA. This scale appears repeatedly in biology. Also TGD inspired model for high T_c superconductivity involves this scale. The length scales corresponding to $L_e(k) = \sqrt{5}L(k)$, $k = 157, 163, 167$ are obtained from $L_e(151)$ by scaling with $2^{(k-151)/2}$. Note that $L_e(167) = 2.5$ μ m corresponds roughly to the size of cell nucleus.

Effects on stoichiometry of water as indication for the presence of dark protons

It is stated that the stoichiometry of water is modified in the activation process but it is not stated what this actually means. The natural guess that this change reflects the transformation of protons to dark protons. I began to consider seriously the notion of hierarchy of Planck constants as I learned about the observations that in atto-second time scales the stoichiometry of water is anomalous: water behaves as $H_{1.5}O$ rather than H_2O in neutron diffraction and electron scattering as if 1/4 of protons were dark and not visible to the incoming neutron and electron.

Generation of ELF em fields in the activation process

The activation process is known to generate ELF em fields with frequency spectrum in the range $[f_1, f_2] = [0.1 \text{ Hz}, 1 \text{ kHz}]$. Their presence can be deduced from the modification of the dielectric constant in this frequency range. The mechanism is not understood but the properties of the polymer compound must be partially responsible for this.

The TGD based explanation could be in terms of amplitude modulation producing dark photons with frequencies in the range 7-8 Hz, whose interaction with the magnetic field of the polymer compound produces other dark photons as cyclotron photons with large \hbar_{eff} and energy proportional to $E_c = \hbar_{eff} \times ZeB/M$, where Z and M are charge and mass of the ion. For instance, the energies of various dark ions at the possibly dark magnetic flux tubes of the magnetic field created by the system are in the frequency range considered.

An alternative interpretation is encouraged by the TGD inspired model of water memory and homeopathy involving dark proton sequences as representations of DNA, mRNA, tRNA, and amino-acid sequences inspired by the observation that the states of dark proton are in one-one correspondence with states of these basic bio-polymers and that vertebrate genetic code follows naturally. The finding of Hu and Wu [J82] in turn leads to the proposal that dark DNA sequences are realized as dark DNA double strands assignable to cell membrane which is also layer like structure. Could it be that the water layers carry parallel pairs of dark DNA strands and that these generate the radiation in the frequency range $[f_1, f_2] = [0.1 \text{ Hz}, 1 \text{ kHz}]$? These dark DNA sequences would give for the water its ability to mimic various molecules by reproducing their

cyclotron frequency spectrum. This would require only the tuning of flux tube thickness to tune the value of magnetic field dictating the value of the cyclotron frequency.

The emergence of frequencies relevant to biology might be due the fact that all four biologically important Gaussian Mersennes might be involved with the fractal hierarchy of the rings. In any case, the first guess is that these frequencies are associated with dark photons with energy of visible photon (with energy say 2 eV for red light) and Planck constant varying in the range $\hbar_{eff}/\hbar = N \in [f_h/f_2, f_h/f_1] = [5 \times 10^{11}, 5 \times 10^{15}]$.

The notion of imprinting of water by frequencies of incoming radiation is essential in the attempts to understand water memory [J28]. Imprinting means that water generates radiation with frequencies used in imprinting and in this sense remembers them. Homeopathic effects can be indeed produced by using only certain imprinted frequencies characterizing the molecule causing the effects on water and stored in computer memory.

This raises some questions. Are the ELF frequencies in question imprinted from those produced by the polymer? Do they correspond directly to cyclotron frequencies assignable to the magnetic field created by it? Does also the homeopathic treatment of water produce activated water with detectable layer structures?

Could the analog of activation process be involved with the emergence of ordered water in cell interior?

Suppose that the activated water is indeed ordered water as the authors of the book suggest. One of the basic steps of evolution is the formation of ordered water in cell interior stabilizing DNA. Could the structure of the activation process allow to guess what might have happened at this crucial step?

1. Earth's magnetic field should have played important role in the prebiotic evolution and the Schumann resonance frequency depending only on the inverse of the radius of Earth in the first approximation should correspond to the ELF frequency used in the activation process. Solar photons would replace the visible photons used in the activation process. A good guess is that Schumann resonance produces an ELF modulation of the visible light from Sun and produces ELF radiation with large value of \hbar_{eff} . If one takes seriously the proposed model of Expanding Earth, the radius of Earth would have been by a factor of 1/2 smaller than its recent radius during primordial period (and therefore equal to the radius of Mars) so that Schumann resonance frequency would have been around 15.6 Hz.
2. What could be the counterpart of the polymer compound? It is difficult to imagine any other candidate than polymers of Si, which is chemically very similar to carbon. Silicates (see <http://tinyurl.com/yclt6x4f>) and clay minerals represent basic example of this kind of polymer structure and have been proposed by Cairns-Smith (see <http://tinyurl.com/y8wfyha4>) [I56] to be a predecessor of life. For instance, the shales of clay can replicate by dividing into two and this replication mechanism might have preceded more refined replication. During the primordial states the replication of layers of clay might have induced the replication of flux sheets in 1-1 correspondence with them.
3. If ordinary photons are transformed to dark photons, they can penetrate Earth's crust through without difficulties. This brings in mind also the TGD inspired vision about the evolution of life in water reservoirs inside Earth, where it is sheltered from cosmic radiation and meteoric bombardment [L68].
4. One can imagine that the irradiation producing dark photons and the presence of the Earth's magnetic field (and possible additional magnetic field) could transform the water to ordered water and provide it with the ability to store memories. If the dark variants of biomolecules are generated by the proposed mechanisms, water would learn to recognize and mimic various molecules. At this step also pairs formed by receptors and molecules binding to them having same cyclotron frequencies and able to attach together and react in the case that the surface geometries are consistent would have emerged.

Does the activated water inherit the layered fractal structure of the polymer compound?

There are several questions to be answered.

1. The complex structure of the polymer compound could be reflected in the structure of light emitted by it as a response to the incoming light. If the photons transform to dark photons in amplitude modulation, and if the polymer compound is ordinary matter, its structure need not be reflected in the structure of the spectrum of dark photons and basic factor is the decomposition of $\hbar_{eff}/\hbar = N$ to integers defining the spectrum of the \hbar_{eff}/\hbar . This is quite a strong prediction.
2. Does the thickness of the flux tubes and/or flux sheets emanating from the magnets depend on the magnets only or does the presence of polymer compound modify them? The layered structure of the polymer compound could indeed induce a layered structure of the magnetic field as parallel flux sheets continuing outside the polymer structure and to the ordered water and induce to it a layered structure. The flux sheets would be parallel to the layers of ordered water. If the flux penetrates as flux tubes, the layers would be generated by some other mechanism and are most naturally be orthogonal to the flux tubes. The experimenters could probably tell what the orientation of the layers is.

Extrapolating to the case of cell membrane, one can ask whether cell membranes and also the complex fractal structure of endoplasmic reticulum corresponds to a magnetic flux penetrating into super conductor of type I near criticality as complex sheet like structure proposed earlier [K23] and whether these flux sheets can be assigned to the Earth's magnetic field.

The intensity of the magnetic field at sheets decreases with the distance from the dipole unless the density of sheets decreases. In an experiment involving rotating magnetic systems the concentration of the magnetic flux to flux walls with constant distance was observed [H18]: this would conform with the idea that flux sheets induce the layered structure of the activated water.

The flux tubes connecting dark protons of dark DNA would be orthogonal to the flux flowing along the flux sheets so that their origin would not be due to the external magnetic field. Of course, protons themselves generate these magnetic field so that this is not a problem. These flux tubes could also carry monopole flux.

3. Are the cyclotron frequencies assigned with the structures of polymer compound imprinted in water? This only requires that the flux tubes possibly emanating from the polymer preserve their thickness. This means obviously deviation from Maxwell's theory where field intensity decreases. For flux sheets the reconnection mechanism does not work.

Chapter 7

Could cancer be a disease of magnetic body?

7.1 Introduction

I received from Prof. Dana Flavin a link to an extremely interesting popular article “*A Unified Theory of Weak Magnetic Field Action*” by L Slesin, editor of Microwave News published in in EMFact (see <http://tinyurl.com/yd4jpuq6>). The article tells about the work of karyologists Ying Li and Paul Heroux. Karyology is a branch of biology studying chromosomes. The research article “*Extra-low-frequency magnetic fields alter cancer cells through metabolic restriction*” by Li and Heroux is published “*Electromagnetic Biology ad Medicine*” [?] (see <http://tinyurl.com/y91v47qp>).

7.1.1 Experimental findings of Li and Heroux

The abstract of the article is following.

Background: *Biological effects of extra-low-frequency (ELF) magnetic fields (MFs) have lacked a credible mechanism of interaction between MFs and living material. Objectives: To examine the effect of ELF-MFs on cancer cells. Methods: Five cancer cell lines were exposed to ELF-MFs within the range of 0.025–5 μ T, and the cells were examined for karyotype changes after 6d.*

Results: *All cancer cells lines lost chromosomes from MF exposure, with a mostly flat dose-response. Constant MF exposures for three weeks allow a rising return to the baseline, unperturbed karyotypes. From this point, small MF increases or decreases are again capable of inducing karyotype contractions (KCs). Our data suggest that the KCs are caused by MF interference with mitochondria’s adenosine triphosphate synthase (ATPS), compensated by the action of adenosine monophosphate-activated protein kinase (AMPK). The effects of MFs are similar to those of the ATPS inhibitor, oligomycin. They are amplified by metformin, an AMPK stimulator, and attenuated by resistin, an AMPK inhibitor. Over environmental MFs, KCs of various cancer cell lines show exceptionally wide and flat dose-responses, except for those of erythroleukemia cells, which display a progressive rise from 0.025 to 0.4 μ T.*

Conclusions: *The biological effects of MFs are connected to an alteration in the structure of water that impedes the flux of protons in ATPS channels. These results may be environmentally important, in view of the central roles played in human physiology by ATPS and AMPK, particularly in their links to diabetes, cancer and longevity.*

Li and Heroux count the number of chromosomes in cancer cell population before and after a irradiation with 60 Hz oscillating magnetic field, which is extremely weak, with strength above 25 nT. Unlike normal human cells with 46 chromosomes, cancer cells have a variable number of chromosomes (typically this causes trouble, Down’s syndrome is one example). Plants have very

often this kind of replication of chromosomes and have isolated cells. Could the replication be due to an effective isolation of cancer cells from each other due caused by a loss of coherent behavior.

Cancer cells typically 74 chromosomes. Li and Heroux report that the irradiation using extremely weak magnetic 60 Hz fields as low as 25-50 nT for 6 days, the cells lose 190 per cent of their chromosomes. They call the effect karyotype contraction.

They repeated the experiment with 4 other cell lines - lung and colon cancer and two different types of leukemias and found essentially the same effect every time.

1. After 3 weeks on the field, the number of chromosomes returns to baseline numbers.
2. Once adapted to the magnetic field, the cells become exquisitely sensitive to further variations of the magnetic field. An increase or decrease of only 10 nT will prompt another round of karyotype contractions.
3. The karyotype contractions vary very little over a wide range of field intensities: from 100 500 nT so that only frequency seems to matter.

7.1.2 The proposed interpretation of findings of Li and Heroux

The interpretation of the findings in the standard physics framework is far from obvious. So weak magnetic fields should not have so strong effects on cancer cell population. Li and Heroux locate the problem to ATPase molecules acting as kind of power plants of cell associated with mitochondrial membrane. ATPase pumps protons against potential gradient and when protons return back, they provide their energy for the formation of ATP serving as the metabolic energy currency of cell. The basic observation is that that the impairing the action of ATPase leads also to karyotype contraction and in the long run makes cells normal. This happens if the cell does not receive enough oxygen in which case anaerobic metabolism starts and produces lactic acid.

From this Li and Heroux conclude that the problem is too high rate for the metabolic energy and that the irradiation reduces the metabolic energy feed by somehow changing the properties of ATPase. They suggests that the weak oscillating magnetic field affects the physical properties of water in the ATPase. The flow of protons becomes slower and the rate of metabolism becomes slower. One could imagine that the conductivity of protons is reduced.

Li and Heroux refer to the article (see <http://tinyurl.com/yd7kqnzg>) *Effect of weak magnetic fields on the properties of water and ice* by Russian physicists L Semikina and V Kiselev [146] (see <http://tinyurl.com/yd7kqnzg>). They show that magnetic fields with strengths in the range 7 Gauss - 2 nT and with frequencies in the range .01-200 Hz have measurable effects on the properties of water. A possible mechanism would be reduction of proton conductivity.

The abstract of the article is here.

We establish that a number of physical properties of water and ice are significantly changed by an alternating magnetic field of a certain frequency. The changes in the physical parameters of ice are several times stronger than the changes in the corresponding parameters of water. Heating water to 50 °C destroys the magnetic effects. When the field is much weaker than the geomagnetic field, a change in water purity (bidistilled instead of distilled water) only broadens the extrema observed in the state dependences of water and ice on the frequency of the alternating magnetic field of constant amplitude. The magnitude and intensity of these extrema are unaffected by water purity. The effects of the geomagnetic field on the properties of ice and water are also discussed.

One important observation is that the effects of ELF em fields depend very weakly on strength but depend on frequency. In standard physics it is difficult to understand this.

7.1.3 Criticism

There are at least two objection against the interpretation of the findings proposed by Li and Heroux.

1. First objection relates to what happens in real cancer as compared to cancer in cell lines. One can argue that cell lines is different from real cancer tissue because they live in a “luxury” whereas real cancer cells suffer from the lack of oxygen. Reduction of metabolic energy feed seems to bring the cells to normal state. Could too high feed of metabolic energy transform ordinary cells to cancer cells? Why? Could the primary reason for cancer be something else than too high metabolic energy feed and be in action also in the real cancer tissue suffering from too low oxygen feed. Could the too low oxygen feed be an attempt of organism to get rid of cancer cells or force them to act like ordinary cells? What could this primary reason for cancer be?
2. Physicist inside me objects strongly the proposed explanation for the return of normal state. Reduction of metabolism could explain it but the magnetic fields seem quite too weak to reduce the rate of proton flow.

A leading example is provided by sociology - I have a concrete experience from my own country at 90's. Things were extremely well but then something strange happened. People became extremely greedy and selfish and kind of manic consumption emerged. Intensive financial speculation began and eventually led to a very bad economical depression. Trust disappeared from the society and social structures started to decay, and loneliness is the basic problem of quite many people nowadays. Social coherence was lost and during decades the situation has become even worse as society has split into rich and poor. Civilizations have life cycle beginning with healthy social structures and ending up to a deeply corrupted deeply divided civilization eventually collapsing. The collapse of civilization means very hard times for individuals but leads to a new civilization with healthy social structures. Do good times have the effect that people do not need each other anymore and this leads to a loss of coherence.

What happened was very much like cancer in which tissue decomposes into cells with only one goal which is to replicate. In the case of bacteria populations it has been found that starvation leads to a formation of analogs of multi-cellulars. The opposite happens in the case of cancer.

In a framework of quantum physics based theory of consciousness predicting a hierarchy of conscious entities [K127] it is rather natural to apply same principles in attempts to understand the behaviour of human society and cell community. Could hard times have a healthy effect also on cancer cell line living in luxury? Could the primary reason for the return of normal state be the generation of coherent less selfish behavior of cells leading also to a restriction of metabolism.

What the coherent behaviour of the population does mean physically, what does induce it? Standard physics does not provide any obvious answer.

7.1.4 TGD based model

TGD based model for the findings relies on some central aspects of TGD inspired quantum biology summarized first. Some new important details related to the magnetic body (MB), dark matter hierarchy labelled by the value of Planck constant h_{eff} , and the notion of gravitational Planck constant h_{gr} are discussed. The TGD based view about water memory and homeopathy are introduced. The basic mechanism is the entrainment of the MB of water to frequencies of external em signals by varying the thickness of its flux tubes so that cyclotron frequencies are tuned to resonance. Kind of living radio set also able to serve as a sender is in question.

The model is applied to two situations. The first application is to the earlier findings by Montagnier's group [I103] about remote regeneration of DNA discussed already earlier in TGD context [L11]. There are two samples A and B. The remote regeneration of DNA occurs in B in absence of template and without any physical contact to A serving effectively as a template. A contains originally the DNA but is extremely diluted.

Second application is a model of cancer applied to the experiments of Li and Heroux. The MB of water would go out of synch from central control frequencies or lose part of its MB generating these frequencies. The proposed healing mechanism would be “homeopathic” treatment by water entrained to the missing control frequencies.

The third application is to the findings of Walter Rawls Jr. about the effects of 2 Tesla magnetic fields on mice [I142]. The findings are not published in any respected journal but their potential implications are enormous. The findings fit nicely with the TGD view explaining above

findings. One also ends up to a concrete proposal for the function of magnetite in brain and even to an idea about magnetic healing. Hence comments about the claimed findings are in order.

7.2 Some aspects of TGD inspired quantum biology

TGD based explanation for the findings relies on the basic notions of TGD inspired quantum biology. The basic notions are magnetic body (MB) and hierarchy of Planck constants $h_{eff} = n \times h_0$ [K36, K37, K38, K39, K88] emerging from the adelic physics as a prediction [L55, L56] but originally proposed on basis of anomalous effects of ELF em fields in living matter. The anatomy of MB has remained unclear hitherto but in this article a detailed model allowing to understand the formula $h_{gr} = h_{eff}$ for gravitational Planck constant and leading to a further formula for h_{gr} relating magnetism and gravitation.

A further central notion is TGD based model for water memory as the ability of the MB of water to control the thickness of its flux tubes to entrain with external frequencies and reproduce them. This is a central element in TGD based view about immune system and homeopathic effects [K58]. Cancer would reduce to a disease of the MB of the living system to high degree determined by the MB of water. Details of the bio-chemistry and even cell membrane dynamics would have surprisingly minor role in the model.

7.2.1 Is the cosmological constant really understood?

The interpretation of the coefficient of the volume term as cosmological constant has been a long-standing interpretational issue and caused many moments of despair during years. The intuitive picture has been that cosmological constant obeys p-adic length scale evolution meaning that Λ would behave like $1/L_p^2 = 1/p \simeq 1/2^k$ [K15].

This would solve the problems due to the huge value of Λ predicted in GRT approach: the smoothed out behavior of Λ would be $\Lambda \propto 1/a^2$, a light-cone proper time defining cosmic time, and the recent value of Λ - or rather, its value in length scale corresponding to the size scale of the observed Universe - would be extremely small. In the very early Universe - in very short length scales - Λ would be large.

It has however turned out that I have not really understood how this evolution could emerge! Twistor lift seems to allow only a very slow (logarithmic) p-adic length scale evolution of Λ [L77]. Is there any cure to this problem?

1. Could one consider the *total* action for preferred extremals - at least flux tubes - as proportional to effective cosmological constant Λ_{eff} ? Since magnetic energy decreases with the are of string like $1/p \simeq 1/2^k$, where p defines the transversal length scale of the flux tube, one would have effective p-adic coupling constant evolution of Λ_{eff} approaching to Λ , which must be extremely small.

The corresponding size scale would correspond to the density of the magnetic energy equal to that of dark energy. Flux tubes with quantized flux would have thickness determined by the length scale defined by the density of dark energy: $L \sim \rho_{vac}^{-1/4}$, $\rho_{dark} = \Lambda/8\pi G$. $\rho_{vac} \sim 10^{-47} \text{ GeV}^4$ (see <http://tinyurl.com/k4bwlzu>) would give $L \sim 1 \text{ mm}$, which would could be interpreted as a biological length scale (maybe even neuronal length scale).

2. But can Λ be very small? In the simplest picture based on dimensionally reduced 6-D Kähler action this term is not small in comparison with the Kähler action! If the twistor spheres of M^4 and CP_2 give the same contribution to the induced Kähler form at twistor sphere of X^4 , this term has maximal possible value!

The original discussions in [K129, K15] treated the volume term and Kähler term in the dimensionally reduced action as independent terms and Λ was chosen freely. This is however not the case since the coefficients of both terms are proportional to $1/\alpha_K^2 S$, where S is the area of the twistor sphere which is same for the twistor spaces of M^4 and CP_2 if CP_2 size defines the only fundamental length scale. I did not even recognize this mistake.

The proposed fast p-adic evolution of the cosmological constant would have extremely beautiful consequences. Could the original intuitive picture be wrong, or could the desired p-adic length

scale evolution for Λ be possible after all? Could dynamics somehow give it? To see what can happen one must look in more detail the induction of twistor structure.

1. The induction of the twistor structure by dimensional reduction involves the identification of the twistor spheres S^2 of the geometric twistor spaces $T(M^4) = M^4 \times S^2(M^4)$ and of T_{CP_2} having $S^2(CP_2)$ as fiber space. What this means that one can take the coordinates of say $S^2(M^4)$ as coordinates and embedding map maps $S^2(M^4)$ to $S^2(CP_2)$. The twistor spheres $S^2(M^4)$ and $S^2(CP_2)$ have in the minimal scenario same radius $R(CP_2)$ (radius of the geodesic sphere of CP_2). The identification map is unique apart from $SO(3)$ rotation R of either twistor sphere. Could one consider the possibility that R is not trivial and that the induced Kähler forms could almost cancel each other?
2. The induced Kähler form is sum of the Kähler forms induced from $S^2(M^4)$ and $S^2(CP_2)$ and since Kähler forms are same apart from a rotation in the common S^2 coordinates, one has $J_{ind} = J + R(J)$, where R denotes the rotation. The sum is $J_{ind} = 2J$ if the relative rotation is trivial and $J_{ind} = 0$ if R corresponds to a rotation $\Theta \rightarrow \Theta + \pi$ changing the sign of $J = \sin(\Theta)d\Theta \wedge d\Phi$.
3. Could p-adic length scale evolution for Λ correspond to a sequence of rotations - in the simplest case $\Theta \rightarrow \Theta + \Delta_k \Theta$ taking gradually J from $2J$ at very short length scales to $J = 0$ corresponding to $\Delta_\infty \Theta = \pi$ at very long length scales? A suitable spectrum for $\Delta_k(\Theta)$ could reproduce the proposal $\Lambda \propto 2^{-k}$ for Λ .
4. One can of course ask whether the resulting induced twistor structure is acceptable. Certainly it is not equivalent with the standard twistor structure. In particular, the condition $J^2 = -g$ is lost. In the case of induced Kähler form at X^4 this condition is also lost. For spinor structure the induction guarantees the existence and uniqueness of the spinor structure, and the same applies also to the induced twistor structure being together with the unique properties of twistor spaces of M^4 and CP_2 the key motivation for the notion.
5. Could field equations associated with the dimensional reduction allow p-adic length scale evolution in this sense?
 - (a) The sum $J + R(J)$ defining the induced Kähler form in $S^2(X^4)$ is covariantly constant since both terms are covariantly constant by the rotational covariance of J .
 - (b) The embeddings of $S^2(X^4)$ as twistor sphere of space-time surface to both spheres are holomorphic since rotations are represented as holomorphic transformations. This in turn implies that the second fundamental form in complex coordinates is a tensor having only components of type $(1, 1)$ and $(-1, -1)$ whereas metric and energy momentum tensor have only components of type $(1, -1)$ and $(-1, 1)$. Therefore all contractions appearing in field equations vanish identically and $S^2(X^4)$ is minimal surface and Kähler current in $S^2(X^4)$ vanishes since it involves components of the trace of second fundamental form. Field equations are indeed satisfied.
 - (c) The solution of field equations becomes a family of space-time surfaces parametrized by the values of the cosmological constant Λ as function of S^2 coordinates satisfying $\Lambda/8\pi G = \rho_{vac} = J \wedge (*J)(S^2)$. In long length scales the variation range of Λ would become arbitrary small.
6. If the minimal surface equations solve separately field equations for the volume term and Kähler action everywhere apart from a discrete set of singular points, the cosmological constant affects the space-time dynamics only at these points. The physical interpretation of these points is as seats of fundamental fermions at partonic 2-surface at the ends of light-like 3-surfaces defining their orbits (induced metric changes signature at these 3-surfaces). Fermion orbits would be boundaries of fermionic string world sheets.

One would have family of solutions of field equations but particular value of Λ would make itself visible only at the level of elementary fermions by affecting the values of coupling constants. p-Adic coupling constant evolution would be induced by the p-adic coupling

constant evolution for the relative rotations R for the two twistor spheres. Therefore twistor lift would not be mere manner to reproduce cosmological term but determine the dynamics at the level of coupling constant evolution.

7. What is nice that also $\Lambda = 0$ option is possible. This would correspond to the variant of TGD involving only Kähler action regarded as TGD before the emergence of twistor lift. Therefore the nice results about cosmology obtained at this limit would not be lost.

7.2.2 The notion of magnetic body

Magnetic flux tubes and field body/magnetic body (MB) are basic notions of TGD implied by the modification of Maxwellian electrodynamics [K92, K65, K113]. Actually a profound generalization of space-time concept is in question. Magnetic flux tubes are in well-defined sense building bricks of space-time - topological field quanta - and lead to the notion of field body/MB as a field identity assignable to any physical system: in Maxwell's theory and ordinary field theory the fields of different systems superpose and one cannot say about magnetic field in given region of space-time that it would belong to some particular system. In TGD only the effects on test particle for induced fields associated with different space-time sheets with overlapping M^4 projections sum.

The hierarchy of Planck constants $h_{eff} = n \times h_0$, where h_0 is the minimum value of Planck constant, is second key notion. h_0 need not correspond to ordinary Planck constant h and both the observations of Randell Mills [L38] and the model for color vision [L66] suggest that one has $h = 6h_0$. The hierarchy of Planck constants labels a hierarchy of phases of ordinary matter behaving as dark matter.

Magnetic flux tubes would connect molecules, cells and even larger units, which would serve as nodes in (tensor-) networks [B13] [L37]. Flux tubes would serve as correlates for quantum entanglement and replace wormholes in ER-EPR correspondence proposed by Leonard Susskind and Juan Maldacena in 2014 (see <http://tinyurl.com/y7za98cn> and <http://tinyurl.com/ydckw5u7>). In biology and neuroscience these networks would be in a central role. For instance, in brain neuron nets would be associated with them and would serve as correlates for mental images [L48, L67]. The dynamics of mental images would correspond to that for the flux tube networks.

7.2.3 Hierarchy of Planck constants, space-time surfaces as covering spaces, and adelic physics

From the beginning it was clear that $h_{eff}/h = n$ corresponds to the number of sheets for a covering space of some kind. First the covering was assigned with the causal diamonds. Later I assigned it with space-time surfaces but the details of the covering remained unclear. The final identification emerged only in the beginning of 2017.

Number theoretical universality and hierarchy of extensions of rationals

Number theoretical universality (NTU) leads to the notion of adelic space-time surface (monadic manifold) involving a discretization in an extension of rationals defining particular level in the hierarchy of adeles defining evolutionary hierarchy. The formulation of this vision is proposed in [L43, L56, L55].

The key constraint is NTU for adelic space-time containing sheets in the real sector and various p-adic sectors, which are extensions of p-adic number fields induced by an extension of rationals which can contain also powers of a root of e inducing finite-D extension of p-adic numbers (e^p is ordinary p-adic number in Q_p).

One identifies the numbers in the extension of rationals as common for all number fields and demands that embedding space has a discretization in an extension of rationals in the sense that the preferred coordinates of embedding space implied by isometries belong to extension of rationals for the points of number theoretic discretization. This implies that the versions of isometries with group parameters in the extension of rationals act as discrete versions of symmetries. The correspondence between real and p-adic variants of the embedding space is extremely discontinuous for given adelic embedding space (there is hierarchy of them with levels characterized by extensions

of rationals). Space-time surfaces typically contain rather small set of points in the extension ($x^n + yn^2 = z^n$ contains no rationals for $n > 2$!). Hence one expects a discretization with a finite cutoff length at space-time level for sufficiently low space-time dimension $D = 4$ could be enough.

After that one assigns in the real sector an open set to each point of discretization and these open sets define a manifold covering. In p-adic sector one can assign 8:th Cartesian power of ordinary p-adic numbers to each point of number theoretic discretization. This gives both discretization and smooth local manifold structure. What is important is that Galois group of the extension acts on these discretizations and one obtains from a given discretization a covering space with the number of sheets equal to a factor of the order of Galois group.

Effective Planck constant as dimension of extension of rationals and number of sheets of space-time surface as covering space

$h_{eff}/h_0 = n$ was identified from the beginning as the number of sheets of poly-sheeted covering assignable to space-time surface. The number n of sheets would naturally a factor of the order of Galois group implying $h_{eff}/h = n$ bound to increase during number theoretic evolution so that the algebraic complexity increases. Note that WCW decomposes into sectors corresponding to the extensions of rationals and the dimension of the extension is bound to increase in the long run by localizations to various sectors in self measurements [K73]. Dark matter hierarchy represents number theoretical/adelic physics and therefore has now rather rigorous mathematical justification. It is however good to recall that $h_{eff}/h = n$ hypothesis emerged from an experimental anomaly: radiation at ELF frequencies had quantal effects of vertebrate brain impossible in standard quantum theory since the energies $E = hf$ of photons are ridiculously small as compared to thermal energy.

Indeed, since n is positive integer evolution is analogous to a diffusion in half-line and n unavoidably increases in the long run just as the particle diffuses farther away from origin (by looking what gradually happens near paper basket one understands what this means). The increase of n implies the increase of maximal negentropy and thus of negentropy. Negentropy Maximization Principle (NMP) follows from adelic physics alone and there is no need to postulate it separately. Things get better in the long run although we do not live in the best possible world as Leibniz who first proposed the notion of monad proposed!

Formula for the gravitational Planck constant and some background

The formula

$$\hbar_{gr} = \frac{GM_D m}{v_0} \quad (7.2.1)$$

for the gravitational Planck constant was originally introduced by Nottale [E2]. Here v_0 is a parameter with dimensions of velocity: I have considered argument allowing to deduce information about the value of $\beta_0 = v_0/c$ as the ratio of the M^4 size of the system and the size of its magnetic body [L62]. Values of order $\beta_0 \sim 10^{-3}$ are encountered.

Since m disappears from the predictions by Equivalence Principle it is not at all clear what kind limitations one has for m and one can even assume that m corresponds to particle mass without change in predictions. In Nottale's original formula m is mass of planet and M_D the mass of Sun but m could be even mass of elementary particle without change in predictions. The assumption has been $m/M_D \ll 1$. The replacement of M_D with total mass $M_D + m$ and m by reduced mass $M_D m/(M_D + m)$ does not affect the formula and the asymmetry between m and M_D would become more natural asymmetry between total mass and reduced mass.

For $Mm < v_0 m_{Pl}^2$ one must have $\hbar_{gr} = h$, which suggests that quite generally one must have $m \geq \sqrt{v_0} M_{Pl}$ and $M \geq \sqrt{v_0} M_{Pl}$. The formula is non-relativistic but one can consider a relativistic generalization in which m and M are replaced by energies [K85].

The formula is expected to hold true at the magnetic flux tubes mediating gravitational interaction. M_D has been interpreted as dark gravitational flux at the gravitational flux tubes with a fixed value of h_{eff} and should be a fraction of the total gravitational flux M . These flux tubes define $n_{gr} = h_{eff}/h_0$ -sheeted covering of M^4 .

Also a more general formula

$$h_{gr} = h_{eff} \quad , \quad h_{eff} = n_{gr} \times h_0 \quad , \quad h = 6h_0 \quad . \quad (7.2.2)$$

has been assumed. The support for the formula $h = 6h_0$ is discussed in [L38, L66]. The value of h_{gr} can be very large unlike the value of h_{eff} associated with say valence bonds.

One important implication of the formula is that the cyclotron energy spectrum does not depend on the mass of charged particle at all and is therefore universal. The assumption has been that the spectrum is in visible and UV range assignable to bio-photons [K17, K26]. One can however consider also the possibility that also the energies between the thermal energy at physiological temperature and visible photon energies are allowed.

What does one really mean with gravitational Planck constant?

There are important questions related to the QFT-GRT limit of TGD.

1. What does one mean with space-time as covering space?

The central idea is that space-time corresponds to n -fold covering for $h_{eff} = n \times h_0$. It is not however quite clear what this statement does mean.

1. How the many-sheeted space-time corresponds to the space-time of QFT and GRT? QFT-GRT limit of TGD is defined by identifying the gauge potentials as sums of induced gauge potentials over the space-time sheets. Magnetic field is sum over its values for different space-time sheets. For single sheet the field would be extremely small in the present case as will be found.
2. A central notion associated with the hierarchy of effective Planck constants $h_{eff}/h_0 = n$ giving as a special case $h_{gr} = GMm/v_0$ assigned to the flux tubes mediating gravitational interactions. The most general view is that the space-time itself can be regarded as n -sheeted covering space. A more restricted view is that space-time surface can be regarded as n -sheeted covering of M^4 . But why not n -sheeted covering of CP_2 ? And why not having $n = n_1 \times n_2$ such that one has n_1 -sheeted covering of CP_2 and n_2 -sheeted covering of M^4 as I indeed proposed for more than decade ago [K89] but gave up this notion later and consider only coverings of M^4 ? There is indeed nothing preventing the more general coverings.
3. $n = n_1 \times n_2$ covering can be illustrated for an electric engineer by considering a coil in very thin 3 dimensional slab having thickness L . The small vertical direction would serve as analog of CP_2 . The remaining 2 large dimensions would serve as analog for M^4 . One could try to construct a coil with n loops in the vertical direction but for very large n one would encounter problems since loops would overlap because the thickness of the wire would be larger than available room L/n . There would be some maximum value of n , call it n_{max} .

One could overcome this limit by using the decomposition $n = n_1 \times n_2$ existing if n is prime. In this case one could decompose the coil into n_1 parallel coils in plane having $n_2 \geq n_{max}$ loops in the vertical direction. This provided n_2 is small enough to avoid problems due to finite thickness of the coil. For n prime this does not work but one can of also select n_2 to be maximal and allow the last coil to have less than n_2 loops.

An interesting possibility is that preferred extremal property implies the decomposition $n_{gr} = n_1 \times n_2$ with nearly maximal value of n_2 , which can vary in some limits. Of course, one of the n_2 -coverings of M^4 could be in-complete in the case that n_{gr} is prime or not divisible by nearly maximal value of n_2 . We do not live in ideal Universe, and one can even imagine that the copies of M^4 covering are not exact copies but that n_2 can vary.

4. In the case of $M^4 \times CP_2$ space-time sheet would replace single loop of the coil, and the procedure would be very similar. A highly interesting question is whether preferred extremal property favours the option in which one has as analog of n_1 coils n_1 full copies of n_2 -fold coverings of M^4 at different positions in M^4 and thus defining an n_1 covering of CP_2 in M^4 direction. These positions of copies need not be close to each other but one could still have quantum coherence and this would be essential in TGD inspired quantum biology [L65].

Number theoretic vision [L56, L55] suggests that the sheets could be related by discrete isometries of CP_2 possibly representing the action of Galois group of the extension of rationals defining the adele and since the group is finite sub-group of CP_2 , the number of sheets would be finite.

The finite sub-groups of $SU(3)$ are analogous to the finite sub-groups of $SU(2)$ and if they action is genuinely 3-D they correspond to the symmetries of Platonic solids (tetrahedron, cube, octahedron, icosahedron, dodecahedron). Otherwise one obtains symmetries of polygons and the order of group can be arbitrary large. Similar phenomenon is expected now. In fact the values of n_2 could be quantized in terms of dimensions of discrete coset spaces associated with discrete sub-groups of $SU(3)$. This would give rise to a large variation of n_2 and could perhaps explain the large variation of G identified as $G = R^2(CP_2)/n_2$ suggested by the fountain effect of superfluidity [L71].

5. There are indeed two kinds of values of n : the small values $n = h_{em}/h_0 = n_{em}$ assigned with flux tubes mediating em interaction and appearing already in condensed matter physics [L51, L66, L38] and large values $n = h_{gr}/h_0 = n_{gr}$ associated with gravitational flux tubes. The small values of n would be naturally associated with coverings of CP_2 . The large values $n_{gr} = n_1 \times n_2$ would correspond n_1 -fold coverings of CP_2 consisting of complete n_2 -fold coverings of M^4 . Note that in this picture one can formally define constants $\hbar(M^4) = n_1 \hbar_0$ and $\hbar(CP_2) = n_2 \hbar_0$ as proposed in [K89] for more than decade ago.

2. Planck length as CP_2 radius and identification of gravitational constant G

There is also a puzzle related to the identification of gravitational Planck constant. In TGD framework the only theoretically reasonable identification of Planck length is as CP_2 length $R(CP_2)$, which is roughly $10^{3.5}$ times longer than Planck length [L71]. Otherwise one must introduce the usual Planck length as separate fundamental length. The proposal was that gravitational constant would be defined as $G = R^2(CP_2)/\hbar_{gr}$, $\hbar_{gr} \simeq 10^7 \hbar$. The G indeed varies in un-expectedly wide limits and the fountain effect of superfluidity suggests that the variation can be surprisingly large.

There are however problems.

1. Arbitrary small values of $G = R^2(CP_2)/\hbar_{gr}$ are possible for the values of \hbar_{gr} appearing in the applications: the values of order $n_{gr} \sim 10^{13}$ are encountered in the biological applications. The value range of G is however experimentally rather limited. Something clearly goes wrong with the proposed formula.
2. Schwarzschild radius $r_S = 2GM = 2R^2(CP_2)M/\hbar_{gr}$ would decrease with \hbar_{gr} . One would expect just the opposite since fundamental quantum length scales should scale like \hbar_{gr} .
3. What about Nottale formula [E2] $\hbar_{gr} = GMm/v_0$? Should one require self-consistency and substitute $G = R^2(CP_2)/\hbar_{gr}$ to it to obtain $\hbar_{gr} = \sqrt{R^2(CP_2)Mm/v_0}$. This formula leads to physically un-acceptable predictions, and I have used in all applications $G = G_N$ corresponding to $n_{gr} \sim 10^7$ as the ratio of squares of CP_2 length and ordinary Planck length.

Could one interpret the almost constancy of G by assuming that it corresponds to $\hbar(CP_2) = n_2 \hbar_0$, $n_2 \simeq 10^7$ and nearly maximal except possibly in some special situations? For $n_{gr} = n_1 \times n_2$ the covering corresponding to \hbar_{gr} would be n_1 -fold covering of CP_2 formed from n_1 n_2 -fold coverings of M^4 . For $n_{gr} = n_1 \times n_2$ the covering would decompose to n_1 disjoint M^4 coverings and this would also guarantee that the definition of r_S remains the standard one since only the number of M^4 coverings increases.

If n_2 corresponds to the order of finite subgroup G of $SU(3)$ or number of elements in a coset space G/H of G (itself sub-group for normal sub-group H), one would have very limited number of values of n_2 , and it might be possible to understand the fountain effect of superfluidity [L71] from the symmetries of CP_2 , which would take a role similar to the symmetries associated with Platonic solids. In fact, the smaller value of G in fountain effect would suggest that n_2 in this case is larger than for G_N so that n_2 for G_N would not be maximal.

New constraint between h_{gr} and h_{eff}

Cyclotron frequencies and energies in magnetic field B and charged particle with charge Ze and mass m are proportional to the ZeB/m . The energy spectrum of bio-photons would be covered by a spectrum of magnetic field strengths B . A special field strength $B_{end} = 0.2$ Gauss has emerged in biological applications from the beginning and the first guess is that it defines a lower bound for the spectrum of visible photon energies [L63, L60, L76]. One can fix the value of h_{gr} and therefore of GM_D/v_0 if one requires that dark photon frequency of say $f_l = 10$ Hz corresponds to the lower bound $f_h = 400$ THz for visible frequencies as $h_{gr} = f_h/f_l$: in this case would have $n_{gr} = 4 \times 10^{13}$.

The variation of B means variation of cyclotron frequency and I have proposed that the audible frequencies correspond to a spectrum of B for the flux tubes involved with hearing [K95], and that even 12-note scale represent in terms of rational frequency ratios might have a preferred role [L22, L75].

The formula $h_{gr} = h_{eff}$ is not enough to fix the model completely. A formula fixing the relationship between B and GM_D/v_0 would be needed. This formula should be consistent with $h_{gr} = h_{eff}$. Dimensional analyst would start from the geometry of the situation.

Magnetic flux tubes are characterized by two parameters: length L_c and radius R_B .

1. Length scale naturally corresponds to the cyclotron wave length

$$L_c = \lambda_c = \frac{1}{f_c} = \frac{2\pi m}{ZeB} . \quad (7.2.3)$$

L_c is proportional to the mass m of the charged particle so that charge particles with different mass are with different mass flux tubes with different length and therefore different onion-like layers of MB. Charged dark particles are like books about different topics at different shelves so that living matter is extremely well-organized: something totally different from a chaotic soup of charged ions.

2. The radius of the flux tube is obtained from the flux quantization. For ordinary cylindrical flux tube with constant B the condition is $BS = k\hbar$ and for $S = \pi R^2$ the radius would be

$$R_B(h, k) = \sqrt{\frac{k\hbar}{\pi eB}} = \sqrt{\frac{k}{\pi}} L_B , \quad L_B = \sqrt{\frac{\hbar}{eB}} . \quad (7.2.4)$$

For $k = 1$ and for $B = B_{end} = .2$ Gauss one has $R_B(h, 1) = 3.3 \mu\text{m}$ to be compared with p-adic length scale $L(167) = 2.5 \mu\text{m}$ assignable to Gaussian Mersenne $M_{G,167} = (1+i)^{167} - 1$. Magnetic length L_B is in this case $L_B = 5.8 \mu\text{m}$ slightly larger than $L(169)$.

3. For $h_{eff} = n \times h_0$, $h = 6h_0$ the formula would generalize to

$$R_B(h_{eff}, k) = \sqrt{\frac{k\hbar_{eff}}{\pi eB}} = \sqrt{\frac{n}{6}} R_c(h, k) = \sqrt{\frac{nk}{6}} R_B(h, 1) . \quad (7.2.5)$$

Note that here n is rather small such as the value of n assignable to valence bonds.

4. The natural guess is that this formula applies at the small part of the MB restricted to the “biological body” of the living system defining that part of system, which corresponds to relatively small values of h_{eff} . The value of h_{eff} would indeed vary, being larger than h for instance for valence bonds [L51]. For dark flux tubes with small value of n the radius would be scaled up by \sqrt{n} such as biological system for fixed value of B . Same happens if the value of flux is scaled by m .

For the simplest flux tubes carrying monopole flux having string world sheet as M^4 projection geodesic sphere as CP_2 projection, the cross section is not circular disk but CP_2 geodesic sphere with radius R . In this case R is fixed. The M^4 projection of these objects is however unstable against thickening and for spherical cross section- think of two disks glued along boundaries but having different CP_2 projections, the area is $4\pi R^2$, where R corresponds to the radius of M^4 projection. Area is reduced by factor 4 from that for non-monopole flux tube and radius is reduced by factor 1/2.

One can guess the additional constraint on h_{gr} without more detailed analysis of what MB really is using dimensional analysis and I will postpone this analysis later.

1. The first natural guess is that one has

$$\frac{h_{gr}}{h_0} = n_{gr} = x \frac{L_c}{R_B(h_{eff}, k)} = x(6\pi)^{3/2} \frac{1}{(nk)^{1/2}} \frac{L_B}{l_C(m)} ,$$

$$L_B = \sqrt{\frac{\hbar}{eB}} , \quad l_C(m) = \frac{\hbar}{m} .$$
(7.2.6)

x is some numerical constant. h_{gr}/h_0 is proportional to the ratio l_B/l_C of the magnetic length and Compton length $l_C = \hbar/m$ of the charged particle.

2. Alternative guess replaces the radius of the magnetic flux tube with the magnetic length L_B .

$$\frac{h_{gr}}{h_0} = n_{gr} = x \frac{L_c}{L_B} = x 6^{3/2} \pi \frac{1}{n^{1/2}} \frac{L_B}{l_C(m)} ,$$
(7.2.7)

This formula is related by factor $\sqrt{k\pi}$ to the first formula and has no dependence on h . It is difficult to say anything about exact value of the numerical constant x .

3. h_{gr} is proportional to m so that the formulas are consistent with $h_{gr} = h_{eff}$ formula. Combining these formulas one obtains

$$\frac{GM_D}{h_0 v_0} = \frac{r_S(M_D)}{2} = x 2\pi \sqrt{\frac{n}{6Z}} \sqrt{\frac{\hbar}{eB}} .$$
(7.2.8)

This formula does not depend on m and gives the value of GM_D/v_0 assignable to the flux tubes carrying magnetic field with strength B and particles with charge Z . One can say that the Schwarzschild radius $r_S = 2GM_D$ characterizing M_D is proportional to magnetic length. The first option gives

$$r_S(M_D) = x \times 2 \times 6^{1/2} \pi^{3/2} \frac{1}{(nk)^{1/2}} v_0 l_B .$$
(7.2.9)

For Earth Schwarzschild radius is $r_{S,E} = 8.87$ mm and if $M_D < M_E$ holds true, one obtains for a given value of v_0 upper bound for the magnetic length and therefore lower bound for B . I have considered in [L62] a model for v_0 and combining this model for this formula, one obtains rather strong constraints on the parameters and also on the minimal value of B . The order of magnitude for v_0 is $v_0 \sim 10^{-3}$.

M_D/v_0 would not depend on the mass of the charged particles at the flux tube (universality) but would depend on their charge Z unless the parameter x has a compensating Z -dependence. Therefore electrons and their Cooper pairs would have different value of GMD/v_0 . One could perhaps interpret r_S/v_0 as analog of star radius applying to particular dark matter part of Earth. It would be considerably larger than Schwarzschild radius.

4. Note that the condition $GM_D m/v_0 = n_{gr} \hbar$ can be written as

$$r_S(M_D) = 2n_{gr} l_C . \quad (7.2.10)$$

Estimate of G/G_N from the delocalization at magnetic flux tubes

The following argument is for a situation in which the mass m corresponds to the mass of ion. By Equivalence Principle m however disappears from the formulas involving gravitational interaction of Earth, and cyclotron frequencies remain invariant for cyclotron BE condensate. Therefore the formulas apply for the BE condensate ions with total mass equal to a multiple of Planck mass $m_P = \hbar_0/R$.

The de-localization length of dark matter wave functions in the gravitational field is much longer than for ordinary value of Planck constant: essentially the height to which particle can rise with given initial velocity V_0 in the gravitational field with gravitational constant G . This would conform with the idea that dark particles are delocalized at the flux tubes in the scale of cyclotron wave-length.

The condition that the height h for the orbit equals to cyclotron wavelength gives an estimate for G_N/G . One can estimate the height $h = R - R_E$ from energy conservation assuming that particle has initial vertical velocity V_0 at the surface of Earth and cyclotron wavelength λ_c :

$$\frac{V_0^2}{2} = \frac{G}{G_N} \left[\frac{GM}{R_E} - \frac{GM}{R} \right] ,$$

$$h = \lambda_c = \frac{1}{f_c} = \frac{2\pi m}{neB} .$$

One obtains an estimate for G/G_N as

$$\frac{G}{G_N} = V_0^2 \frac{(R_E + h)R_E}{r_S h} , \quad R = R_E + h ,$$

$$h = \frac{\lambda_c}{n} = \frac{1}{nf_c} = \frac{2\pi m}{neB} . \quad (7.2.11)$$

This gives

$$\frac{G}{G_N} = nV_0^2 \times \frac{R_E(R_E + \frac{\lambda_c}{n})}{r_S \lambda_c} = nV_0^2 \times \frac{R_E(R_E + \frac{2\pi eB}{neBm})}{r_S} \times \frac{eB}{2\pi m} . \quad (7.2.12)$$

The condition that value of G/G_N is constant quantizes the value of V_0 . For small value of h one has $V_0^2 n \simeq \text{constant}$. For $R_E \sim \lambda_c$ and nV_0^2 is of order unity, the order of magnitude would be $G/G_N \sim R_E/r_S \sim 7 \times 10^8$.

7.2.4 What can one say about the detailed anatomy of the MB?

The details of the anatomy of the MB have remained rather fuzzy hitherto. The following is an attempt to formulate more explicitly and coherently the earlier ideas scattered in books and articles about TGD. There are several empirical facts and theoretical constraints that one can use.

1. There is the notion of dark DNA as dark nuclei consisting of sequences of dark protons. The notion of dark nucleus is central concept in TGD based model of “cold fusion” [L49]. Dark proton sequences are parallel with and in the vicinity of ordinary DNA strands and ordinary codons and dark proton triplets representing them [L34] are paired.

2. Pollack effect [L25] [L25] for water is assumed to generate dark DNA. Part of protons go to the flux tube and negative charge is generated in ordinary matter and ends to negative charge of phosphates associated with the ordinary DNA nucleotides. Ordinary DNA would pair with dark DNA serving as predecessor and controller of ordinary DNA. Also RNA, amino-acids, and tRNA would have dark predecessors and similar pairing would occur.
3. Experiments of Peter Gariaev *et al* - in particular the discovery of phantom DNA [I83] - and of Montagnier [I103] [L12] provide further valuable information.

Consider now what MB could look like.

1. MB has two parts. The small part has size of the physical system consisting of ordinary matter plus parts with relatively small h_{eff} assignable to structures such as valence bonds. The flux tubes of this part of MB connect parts of the system to a network and tensor network is an excellent mathematical model for what is involved. Flux tubes serve as topological correlates for entanglement and even prerequisites for it.

In living matter one can imagine that the basic units of ordinary matter - say cells - are organized at parallel flux tubes. For $B_{end} = .2$ Gauss, which seems to define an especially important endogenous magnetic field, the radius r_B is of cell size. The value of proton cyclotron frequency is 300 Hz in this case and happens to correspond to the rotation frequency of the “shaft” of the ATPase as power generator.

60 Hz frequency was found to lead to a transformation of cancer cells to ordinary ones and this suggests that cyclotron frequency for $B = B_{end}/5$ is involved. The flux tubes would contain 5 cells in their cross section and one can argue that dark proton quantum coherence at gravitational flux tubes with this thickness could give rise coherence in 5-cell length scale and lead to the cure of cancer.

2. The large part of MB - with size of the order Earth radius for $f_c = 60$ Hz corresponds to long flux tubes with large effective Planck constant $h_{gr}/h_0 = n$. Effective value of Planck constant is indeed in question since n_{gr} is the number sheets of the space-time surface as covering space and Planck constant has value h_0 (rather than $h = 6h_0$) at each sheet of the covering. At QFT limit sheets are effectively replaced with single one, and one must allow the “real” Planck constant to have non-standard values.

What space-time surface as covering does mean has been already discussed, and it seems that the identification as $n = n_1 \times n_2$ covering, where n_1 is the number of sheets as covering of CP_2 realized in the recent case as disjoint flux tubes in M^4 and n_2 is the number of sheets as covering of M^4 . Gravitational constant identified as $G = R^2/\hbar_2$ would allow to avoid unphysical predictions since n_2 could be limited to a rather narrow range by symmetry considerations.

The cyclotron energies are scaled up by $h_{eff}/h_0 = n_{gr}$ and whatever the detailed anatomy of MB is this must be understood. Effectively one has n_{gr} photons with ordinary cyclotron energy and their energies sum up. This can be understood if the flux tubes define n_{gr} -fold coverings of M^4 .

3. $h_{gr} = n_{gr}h_0$ correspond to quantum coherence in very long length scales whereas in the scale of organism the value of n is relatively small. The simplest idea is that n_{gr} disjoint flux tubes with small value of n and with given thickness determined by flux quantization coming from the living system combine to form single n_{gr} -sheeted flux tube with length given by $L_c = \lambda_c = 2\pi m/ZeB$ having no dependence on h_{eff} .

This would be like a large number of cables combining a single cable. The threads of the cable would be now on top of each other in CP_2 direction! A rather exotic space savings! This would combine the sensory information coming from the separate flux tubes to a single super-cable and make the control of the system easy. Central nervous system would have spinal chord as an analogous unit both geometrically and functionally albeit in totally different scale. One of the first proposals was that MB provides an almost topographic representation of the biological body [K66].

One can estimate the volume of the region with coherence forced by quantum gravitational coherence as $V_{gr} = n_{gr}V(unit)$, where $V(unit)$ is the volume of the basic unit presumably determined by flux tube radius. If $V(unit)$ equals to volume a^3 of cube with side a , V_{gr} corresponds to a cube with side $a_{gr} = n_{gr}^{1/3}a$.

The assumption that the energies of EEG photons in alpha band with $f = 10$ Hz correspond to ordinary photons at the lower end of the bio-photon spectrum having frequency 400 THz gives n_{gr} as $n_{gr} = 4 \times 10^{13}$. For $n_{gr} = 4 \times 10^{13}$ and $a = 5 \mu\text{m}$ giving lower bound for the volume of neuron one would have $a_{gr} = 0.2\text{ m}$, roughly the size scale of brain.

4. The natural interpretation of the super-cables is as gravitational flux tubes. The gravitational flux associated with the ordinary flux tubes would combine to the dark gravitational flux tubes involving n_1 parallel flux tubes in M^4 , each of them consisting of n_2 flux tubes on top of each other in CP_2 direction. This combination could take place repeatedly. Could the parameter M_D in $h_{gr} = n_{gr}h_0$ correspond to the portion of the Earth's gravitational flux flowing along these flux tubes? The sum of the masses M_D should over values of field strengths and charged particle masses should give the total mass M_E of Earth if the guess is correct.

One must of course be extremely cautious in interpretations. For instance, flux tubes carrying Kähler charge the flux tubes should be closed and give rise to a kind of Dirac monopole like structure with return flux. This would mean that gravitational flux returns back, possibly along different space-time sheets. But the flux lines are closed also for the ordinary magnetic fields. Can this really be consistent with the Newtonian view about gravitation in which gravitational flux flows to infinity? The answer is far from obvious: the many-sheeted space-time in which space-time sheets are glued along the boundaries would that part of the flux can return and part goes to larger space-time sheets and in principle there is no largest space-time sheet so that one would obtain effectively monopoles.

5. An entire fractal hierarchy of magnetic field strengths is predicted. A good guess is that field strengths are given by p-adic length scale hypothesis, that is have scales given by $B(k) \propto 1/L(k)^2$, where $L(k) \propto 2^{k/2}$ is the p-adic length scale assignable to $p \simeq 2^k$. This would mean hierarchy of flux tubes with radii $L(k)$ and at each level the combination to super-cables representing gravitational flux tubes would take place.

One has $M_D \propto v_0/\sqrt{B} \propto v_0 2^{k/2}$. For a fixed value of v_0 , the sum can converge only if the number of p-adic length scales involved is finite. The radius R_E of Earth certainly gives this kind of upper bound and corresponds to a rather modest value of k ($L(151)$ correspond to 10 nm). Also v_0 can depend on p-adic length scale. The sizes of living organisms give a more stringent upper bound on k .

7.2.5 Water memory and homeopathy

There is a lot of support about the representation of water memory as extremely low frequencies (ELF) of radiation associated with water [I74, I75]. These ELF frequencies can be stored electronically and they produce the same effects as the bio-active chemical, whose presence induced these frequencies in water. At the age of IT the idea about the existence of representations of bio-active molecules as frequency patterns able to induce the biological effects of molecules without the presence of molecules should not raise grave objections. For instance, brain generates this kind of representations by entrainment to external frequencies and water might play a crucial role also here. Few years ago HIV Nobelist Montagnier did experiments giving support for water memory and the procedure involved a part very similar to that used in preparing homeopathic remedies [I103] [L12].

The description of water memory in TGD Universe would look like follows.

1. In TGD framework these frequencies would correspond to cyclotron frequencies assignable to MBs of molecules, and immune system is proposed to have emerged from the ability of water to mimic the MBs of invader molecules and learning to recognize them [K58] by resonant coupling at these frequencies.

This would take place via entrainment made possible by the variation of the thickness of the flux tube inducing variation of the cyclotron frequency. In entrainment the cyclotron frequency of the flux tube would coincide with the external frequency. MB having flux tubes with modified thickness would be able to produce cyclotron radiation at these frequencies and couple to the invader molecule resonantly. The coupling would involve also topological part as reconnection of flux tubes with same thickness and carrying same charged particles to make resonance possible.

One can visualize living systems as systems having magnetic tentacles consisting of U-shaped flux tubes forming thus locally pairs of flux tube tubes and searching for flux similar flux tubes of other systems, in particular bio-active molecules. The recognition of invader molecules is a crucial part of immune systems and this mechanism would be an essential part of immune action besides cyclotron resonance.

2. In TGD universe water is very special substance in that it contains both ordinary water and its dark variant. What makes it dark is that dark magnetic flux tubes representing long hydrogen bonds are present for some portion of water [L72] (see <http://tinyurl.com/y8fvwbp9>): the length of bonds scales as n or perhaps even n^2 . The presence of these flux tubes makes any liquid phase a network like structure, and one ends up with a model explaining an anomaly of thermodynamics of liquids at criticality known already in Maxwell's time. This leads to a model explaining the numerous anomalies of water in terms of the dark matter.

For instance, the dark part of water with non-standard Planck constant transforms to ordinary water in freezing. As a consequence, a large amount of energy is liberated. This explains why water has anomalously large latent heat of fusion. One can also understand why the volume of water increases in freezing and decreases in heating in the interval 0-4 °C. The anomalies of water are largest at physiological temperature $T_{phys} \sim 37$ °C suggesting that the dark portion of water is largest at T_{phys} . Dark fraction of water would be essential for life.

3. Pollack effect [L25] (see <http://tinyurl.com/oyhstc2>) requiring feed of energy - as IR radiation for instance - generates so called exclusion zones (EZs), which are negatively charged regions. A fraction of protons from water must go somewhere and the TGD inspired proposal [L25] (see <http://tinyurl.com/gwasd8o>) is that the protons transform to dark protons at magnetic flux tubes. The dark variants of particles quite generally have higher energies than ordinary ones and energy feed provides the needed metabolic energy to make the protons dark. In the case of homeopathy and water memory mechanical agitation creates provides the metabolic energy and would generate EZs accompanied by dark proton sequences at flux tubes [K58].
4. The MB of water would be also a key central part of MB of the living system acting as intentional agent receiving sensory input from biological body and controlling it. Biochemistry would be kind of shadow dynamics. The ions provided by the living system would reside at the flux tubes of MB provided by water and as found the lengths of flux tubes and also the value of $h_{eff} = h_{gr}$ at the would distinguish between different ions. The gravitational flux tubes formed by combination of n_{gr} ordinary flux tubes to n_{gr} flux tubes with the same M^4 projection defining a covering of M^4 would define the large part of MB serving as intentional agent and communications would occur at cyclotron frequencies.

Cell membranes would produce what I call generalized Josephson radiation, which would couple resonantly to cyclotron Bose-Einstein condensates at the flux tubes. Nerve pulse patterns would induce frequency modulation allowing to code sensory input represented by them and send it to MB which in turn could send control signals through genome [K96, K44, K3, K135].

MB would be the seat of primary form of genetic code. Dark proton sequences at flux tubes representing genetic code [L34] and the analogs of the other basic biomolecules are realized in water.

7.2.6 What the view about magnetic body could mean at the level of DNA and other basic bio-molecules?

A more precise vision about the anatomy of MB leads to a flux of ideas and questions. Flux tubes from identical basic units (cells, DNA, identical proteins, etc) combine to form single many-sheeted flux tube so that the incoming flux tubes have same M^4 projection being on top of each other in CP_2 direction. This super cable is like umbilical chord! The structures form a Bose-Einstein condensate in abstract topological sense.

This opens fascinating possibilities for understanding of dark DNA.

1. Cells have identical DNAs. Earlier I have assumed that magnetic flux sheets go through DNA in transversal direction and that dark DNA in some sense is sequence of dark proton triplets associated with flux tubes. Furthermore, DNA transcription requires that there are transversal flux tubes emerging from codons or perhaps even from nucleotides as flux tubes inside codon flux tube.

How to combine these views together with new view about combination of the DNAs flux tube to larger superstructure, one DNA from each cell in structure?

2. For single DNA each codon would correspond to 3-proton units organized linearly into a sequence. Each 3-proton unit must have a flux tube transversal flux to DNA strand and located at 2-D sheet. This brings in mind the structure of spine as anatomical and neurobiological analogy. This suggests that dark DNA codons formed by 3-proton units should be associated with these horizontal flux tubes in 2-D locally planar surface going through DNA.
3. These structures from $n_{gr} = h_{gr}/h_0 = h_{eff}/h_0$ separate cells should combine to single n_{gr} -sheeted gravitational flux tube with sheets on top of each other with same M^4 projection. This would be dark DNA at the level of MB. It would seem that given codon of each DNA must contribute a dark proton triplet so that there would be n_{gr} dark proton triplets at given flux tube which is however very long. The size scale - that is the length of the flux tube - is that of Earth typically and fixed by the cyclotron wave length λ_c .

This would give a concrete topological meaning to quantum quantum coherence at the level of MB of bio-system. Also a view about how lower level conscious entities integrate to larger ones: one can imagine entire fractal hierarchy of structures integrating to larger structures integrating... In particular, altered states of consciousness could correspond to this kind of temporary integrations to higher level structures. Same should apply to other basic biological structures: cells, proteins, RNA, tRNA. Dark realization of the genetic code predicts the dark variants of these biomolecules.

This picture conforms with adelic physics [L55, L56] in which n_{gr} corresponds to the dimension of extension of rationals: the larger the value of n_{gr} , the higher the algebraic complexity and level of conscious intelligence.

4. Where are the dark protons and various dark ions at dark flux tubes? Along entire long flux tubes with length of order cyclotron wavelength for given charged particle? Or inside the organism?

The model of dark DNA allows only the latter option. They must reside at the short portions of the magnetic flux tubes inside organism. For instance, the dark protons of dark DNA are associated with flux tubes parallel and in immediate vicinity of ordinary DNA strand and codon and dark codon a paired like codon and its conjugate in ordinary DNA.

What makes these particles dark is that they are controlled by the gravitational flux tube and form a non-local quantum coherent unit containing n_{gr} particles.

This raises a long series of questions and fantastic challenges for visual imagination.

1. How do DNA and its conjugate relate at this level: do DNA and conjugate correspond to single closed long flux tube forming part of the "umbilical chord" far from biological body?

2. What replication of DNA could mean topologically at the level of this super-DNA? What about description of transcription and translation at these super-levels. Are the ordinary replication, etc.. induced from this super level as mere shadow processes: this would explain their mysterious coherence?
3. What sexual reproduction and associated recombination of chromosomes could mean at super level? What does the growth of organisms mean at super level? Addition of new sheets to super DNA and its variants so that n_{gr} defined as the number of basic units grows and organism becomes more and more quantum intelligent?

7.3 Two applications of the model of magnetic body

In the following the model of MB is applied to explain the findings of Montagnier [I103], and of Li and Heroux [?]. Also the sensational claims of Walter Rawls Jr. [I142] about the effects of 2 Tesla magnetic fields on mice are discussed.

7.3.1 Interpretation of the experiments of Montagnier *et al*

One can make the model of MB more detailed by applying it the experiments of Montagnier *et al* [I103] discussed earlier from TGD viewpoint at [L12]. I have developed in collaboration with Peter Gariaev and analogous model analogous observations [K149].

Consider first a very rough sketch of the experiments.

1. A fragment of DNA was amplified by PCR. It was diluted to say 10^{-6} by adding pure water and found to generate EMS at ULF frequency range .5-3 kHz. Call this sample A.
2. Dilution was put in mu-mental container, which does not allow ULF radiation to get out. In its vicinity another tube, call it B, containing pure water was placed. The water content of each tube was filtered through 450 nm and 20 nm filters. Filtering does not allow particles with size smaller than 20 nm to go through. The samples were diluted to 10^{-15} by adding pure water. During each dilution a mechanical agitation of water by generating a vortex was performed.
3. Copper solenoid producing 7 Hz current was added around the samples. Eventually EMS was found in *both* A and B. In B there was primer, DNA polymerase, and free nucleotides but not the template complementary strand as in ordinary polymerase chain reaction.

The TGD interpretation for what happened in sample A would be following.

1. As explained ordinary DNA strand is paired with dark DNA strand for which dark proton triplets at flux tube parallel to ordinary DNA strand represent the codons [L34]. This is analog of pairing of DNA strand and its conjugate.
2. The cyclotron transitions of dark protons (possibly also those changing the direction of spin) generate the ULF radiation as classical em fields accompanied dark photons transformed to ordinary photons. The energies of dark photons are given by $E = h_{gr}f$ and should be above thermal energy at physiological temperatures. The transformations of dark photons to ordinary photons give rise to bio-photons with energies in visible and UV, and possibly also below this range [K17, K26].
3. Dilution eliminated ordinary DNA from A but left some dark DNA strands to the water. This is nothing but the phantom DNA phenomenon [I83] discovered by Gariaev and collaborators [K145]. In case of water memory one has phantoms of bio-active molecules [K58]. I have applied TGD also to other experimental findings and ideas by Gariaev *et al* [I82, I85, I128]. In particular there are articles written in collaboration about the TGD realization of identification of DNA as hologram [K1] and about DNA remote replication analogous to what happens in Montagnier's experiments [K149].

4. The interpretation of the agitation carried out also in the preparation of homeopathic remedies is that it provided metabolic energy needed to generate large h_{eff} [K58]. Quite generally, the energy of dark variant is larger than that of ordinary state: for instance, cyclotron energy is proportional to h_{eff} and atomic binding energies to $1/h_{eff}^2$ so that metabolic energy is needed.

The analogy with ordinary DNA and the idea that DNA replication is a shadow of the replication of dark DNA suggests that dark DNA replicated and a population of dark DNA mimicking ordinary DNA was generated in the diluted water sample A. More generally, water would perform mimicry of bio-active molecule by using dark protons at its magnetic body to generate the cyclotron frequency spectrum of the molecule. An interesting possibility is that dark proton sequences - dark nuclei - perform this mimicry.

5. The general model suggests that dark DNA generate transversal flux tubes at transversal sheets going through it. One could start by saying loosely that dark photon cyclotron radiation propagated along these flux tubes to the pure water sample, where there was flux tube receiving this radiation. But what the precise meaning of this statement could be, becomes more clear in the following.

What happened in the pure water sample?

1. Dark photon radiation at ULF frequencies should have caused the generation of dark DNA strands also in pure water sample. The water in the pure water sample mimicked the dark photon radiation by the basic homeopathic mechanism and generated dark DNA strands with transversal flux tubes at transversal flux sheets carrying magnetic fields corresponding to the cyclotron frequencies of dark DNA nucleotides.
2. Did a pairing of dark DNA in A and its conjugate in B analogous to the pairing of DNA and its conjugate take place? As in the ordinary DNA pairing the pairing would be favored by the minimization of interaction energy. The flux tubes connecting the members of the pair would be like stretched hydrogen bonds between DNA strand and its conjugate so that it would be very long, of order cyclotron wavelength of proton in the magnetic field of flux tube. TGD indeed predicts that hydrogen bonds have length spectrum corresponding to various values of h_{eff} [L72]. In this case however rather small values are involved. Now the values would be very large by $h_{eff} = h_{gr}$.
3. Did the transversal flux tubes attach to the dark DNA flux tubes directly and have length of the order of distance between samples? Or did the flux tubes from water sample combine to many-sheeted gravitational flux tube with length of the order of cyclotron frequency of proton? The latter option is favored.

The dark photons assignable to the frequency range .5-3 kHz should have energies above thermal energy at physiological temperature in order to have physiological effects. This requires $h_{eff} \geq 6 \times 10^{10}$: $f = .5$ kHz would correspond to a thermal energy of photon for most probable wavelength about 10 μm .

A reasonable estimate for the length of the flux tubes involved comes from the cyclotron wavelength of proton. The cyclotron frequency .5 – 3.0 kHz for proton requires magnetic field about .3 – 2.0 Gauss somewhat stronger than $B_{end} = .2$ Gauss ($B_E = .5$ Gauss). The cyclotron wavelength would be in the range .1-.6 Mm (Earth radius is 6.4 Mm) so that the analogs of hydrogen bonds would be very long!

4. The generation of ordinary DNA strands in this sample would have been by the analog of DNA - dark DNA pairing that should occur in standard biology. The DNA fragment in pure water sample was reproduced as if the complementary strand would have been present.
5. As already explained, the dark protons are at single sheeted ordinary flux tubes accompanying DNA. n_{gr} flux tubes from various positions would combine n_{gr} -sheeted flux tube with same M^4 projection as ordinary flux tube: they were on top of each other in $M^4 \times CP_2$. Why the protons deserved to be called dark is that the proton sequences at n_{gr} separate

flux tubes form single quantum coherent many-proton states somewhat analogous to Bose-Einstein condensate. Cyclotron energy is therefore naturally n_{gr} times the cyclotron energy of single state. This is essentially quantum non-locality made possible by the locality at the gravitational flux tube quantum controlling the system. Also dark photons having n_{gr} -fold energy non-local many-photon states with one photon at each flux tube with same energy and momentum.

6. Also 7 Hz frequency is necessary for the effect to occur. A natural guess is that this frequency is related to Schumann resonances (see <http://tinyurl.com/cv8z9vs>), which are associated with collective oscillations in the Earth's magnetic field in the cavity bounded by Earth's surface and ionosphere in which em waves cannot propagate. Schumann resonances dominate the frequency spectrum from 3 Hz to 60 Hz - a considerable part of EEG - and there are distinct peaks at frequencies resonance 7.81, 14.3, 20.8, 27.3 and 33.8 Hz.

In the linear model Schumann resonances treating atmosphere as vacuum Schumann resonance frequencies $f_n = \sqrt{n(n+1)}c/2\pi R_E$ are determined by the geometry alone with lowest resonance at 7.41 Hz for $R_E = 6371$ km. The finite conductivity of atmosphere lowers the propagation velocity of light and the frequencies are reduced. This can bring the resonance frequency 7.81 Hz nearer to 7 Hz, and there is of course also the continuum besides the resonance peaks.

In TGD picture the quasi-continuum would relate to the many-sheetedness of the space-time surface making it possible for light to propagate along large number of flux tube paths so that the effective light-velocity would vary. A more precise model give also a resonance at 4.11 Hz. This resonance frequency however varies due to the several factors.

The interpretation of Schumann resonances 7.81, 14.3, 20.8, 27.3 and 33.8 Hz and higher resonances as resonance frequencies of EEG is highly attractive. At higher frequencies the resonances appear approximately with 6.5 Hz intervals. Next resonance would be at 40.3 Hz, which is the familiar thalamo-cortical resonance frequency to which consciousness was once assigned. 8:th partial wave has resonance frequency 60 Hz which happens to be the frequency appearing in the experiments of Li and Heroux. 4 Hz frequency in turn is theta resonance frequency in EEG.

This supports the view that water entrains to Schumann frequencies by tuning to cyclotron frequencies by varying the thickness of flux tubes of its MB so that the coupling of living matter to the oscillations of Earth's magnetic field would play fundamental role in biology and neuroscience. The testable prediction is the correlation of EEG with the local Schumann resonance spectrum of Earth independent of individual.

Dr. Phil Callahan [I14, I48] claims on basis of intensive experimental work that there is a tendency of political strifes and wars to concentrate on regions where Schumann resonances are weak. In the proposed picture this would not be surprising. The reduction in the level of consciousness would imply strifes and wars at the level of society and cancer at the level of cell community.

7.3.2 Cancer as a disease of the MB of water?

How the irradiation of the cancer cell population with 60 Hz oscillating magnetic field with extremely small intensity in above 25 nT could lead to the reduction of the chromosome number of mitochondria and return of cancer cells to a normal state?

One should locate the problem. Is the problem at the level of cell membrane, mitochondria, or ATPase as Josephson junction, or possibly at the level of MB of water? Could cancer - and perhaps many other diseases - be diseases of the MB of water? This option is certainly the simplest one since one can forget entire chemistry of cells apart from the presence of charged particles.

What the problem is? Cancer rather obviously means a loss of coherence at the level of ordinary bio-matter forced by quantum coherence at the level of MB. This suggests that the quantum coherence of MB is for some reason lost in cancer. The coherent behavior of cell groups consisting of few cells is lost and cells behave like individuals knowing nothing about each other's presence.

In the recent case one can consider protons in magnetic field $B = B_{end}/5$ with 5 times larger flux tube area increasing the area of quantum control by factor 5: 5 cells instead of 1 cell roughly. One can also consider magnetic field $B = 6B_{end}/5$ with Li^+ ions having mass number $A = 6$. Now the length rather than radius of flux tubes would be scaled up by factor 5. Li^+ ions are indeed applied in manic depressive disease and schizophrenia but the mechanism for healing is unknown. TGD proposal is that their presence generates cyclotron radiation needed to have communications with the layers of MB responsible for the control of axons for instance known to suffer from inflammation [L39, L35].

Let us consider a more detailed model.

1. Assume that MB, whose anatomy has been described above controls bio-matter. The radius of flux tube defines the size scale of coherent regions and the quantum coherence of gravitational part of MB can force coherence in this regions. For cancer cells the radius of this regions is cell radius and flux tubes with this thickness form the basic structural units. For $B_{end} = .2$ Gauss the radius $R_B \simeq 3.2 \mu\text{m}$ of the flux tube is indeed of the order of cell radius. The cyclotron frequency for proton is 300 Hz and this conforms with the idea that it defines the rotation frequency of the shaft of the power generator defined by ATPase.
2. The coherent behavior requires the presence of also higher levels in the p-adic length scale hierarchy. 60 Hz frequency corresponds to cyclotron frequency for dark protons in $B = B_{end}/5$. This does not actually correspond to power of 2 but I have proposed that also powers of other p-adic length scales for small primes could be important and there is evidence for $p = 3$ [K80]. Now one would have $p = 5$. Note that the roots \sqrt{p} , $p \in \{2, 3, 5\}$ are in a central role in the geometry of Platonic solids (the geometry of icosahedron is in central role in one TGD based model of genetic code based on the notion of bio-harmony [L22, L75]).

Since flux tube with 5-fold area contains 5 cells in transversal cross section, this suggests that in cancer the coherent behavior at 5-cell level is lost. It might be that the thickness of these flux tubes has for some reason changed so that they are out of synch or that they are missing altogether.

3. The above summarized experiments of Russians [I46] show that the physical properties of water change by irradiation with extremely weak magnetic fields at frequencies at various frequencies. That the properties of water change would be due to the control action by MB of the water. The effect depends very little on the strength of the field and this conforms with the entrainment hypothesis meaning that flux tubes tune their thickness to achieve resonance like radio set.

TGD interpretation is in terms of water memory. In TGD water memory is represented as cyclotron frequencies associated with the flux tubes of MB of water, its body parts characterized by various frequencies and the body parts, flux tubes, can thicken in which case the frequency is reduced and vice versa. Even new body parts can emerge and it is possible genetic code codes for them (in fact dark genome assignable to protonic flux tubes parallel to DNA would be the fundamental code). MB entrains to external frequencies by varying the thickness of its flux tubes and can respond to and represent them as cyclotron frequencies.

The healing of cancer cells by 60 Hz radiation could bring to the MB of cancer cells the protonic flux tubes with $f_c = 60$ Hz. The communications to the big MB of the cell would be restored and MB could take care of the cell.

4. The above discussed connection with Schumann resonances suggests that all Schumann resonances are fundamental for biology and the MB of water entrains to them. The 8:th Schumann resonance is indeed 60 Hz.

This could have rather far reaching implications.

1. Also the homeopathic treatment of water [K58] is explained in terms of the generation of flux tubes as body parts of MB of water having the cyclotron frequencies of the molecules involved in the treatment. These molecules represent at least the ELF part of the cyclotron energy spectrum of molecules and can therefore couple resonantly to them so that MB can

detect the invader molecules and molecules of immune system can catch them and make them harmless.

The mechanical agitation of water would provide the metabolic energy needed to generate the needed large values of h_{eff} . Quite generally, metabolic energy feed is needed in order to generate MB containing the dark matter. At least the ELF spectrum of homeopathic remedy has been found to generate the same effective as the original molecule, which also demonstrates that it is ELF spectrum, which is responsible for bio-activity. This does not make sense in standard quantum theory since the photon energies are much below the thermal energy at the physiological temperatures. The large value of h_{gr} saves the situation.

2. If this picture is correct, homeopathic remedies could be also generated by irradiation of water using the ELF frequency spectrum characterizing the substance considered.
3. In the case of cancer the irradiation of water with 60 Hz frequency could generate the required body parts of MB or get existing body parts in synch and induce a healing of cancer. Cancer would be very probably only very special case if MB is the intentional agent controlling biological body in various scales and bio-chemistry is a kind of shadow dynamics as suggested. One can even imagine a medicine completely free of the side effects of various chemical medicines [K58]. If even genetic diseases are basically diseases of MB, they might be healed homeopathically. An interesting question is whether water is a kind of universal emulator of various molecules able to very quickly modify its MB.

7.3.3 Mice in magnetic fields

I received from Donald Adams a highly interesting link (see <http://tinyurl.com/ya9438st>) relating to the effects of 2 Tesla magnetic field on mice (much stronger than the Earth's magnetic field). The claims of the article by Walter C. Rawls Jr seem sensational. I do not know whether to trust on the claimed findings since from the viewpoint of TGD inspired quantum biology they seem to be too good to be true. A sociological reason to worry is that the findings are not published in any respected journal. But on the other hand, my own work has not been published in respected journals either and will not be so for years to come. With these reservations and knowing the enormous potentials importance of the findings of Rawls if true, I attach a piece of the article of Rawls [I142].

How animals dramatically change in relation to magnetic field exposure?

Twelve mice were placed in a cage to be used as controls (untreated). Another twelve mice were placed in a separate cage with exposure to the South pole field of a 2,000 gauss magnet, and the last twelve were put in a cage exposed to the North pole energies of a like magnet. An equal number of males and females were put in each cage. Exposure time was two months.

The untreated control mice behaved and functioned as normal mice. Without exception, the South pole mice slowly became very messy in their housekeeping, their appetites increased, they engaged in sex more, and their offspring were larger than those of the controls. Also, as time passed, they became mentally slow, losing sensitivity to sound and light changes in the laboratory. Their young were difficult to teach the customary tests; they were lazy, listless, careless and very dirty in appearance.

The North pole mice became very neat and tidy, cleaning themselves frequently. They also became extremely sensitive to any noise or light variations in the laboratory. Their offspring were smaller than those of the controls. They were mentally superior to the controls and out performed the South pole young by several hundred percent in all phases of natural behavior.

The South pole mice were larger, grew faster, matured sooner, and mated continually. They also died earlier than their control counterparts. The North pole mice matured slower and lived 45 to 50 percent longer than the controls. They were also mentally superior to the controls and several hundred percent smarter than the South pole mice. They were much less frequent with sexual behavior than the South pole treated mice and less than the controls.

Rats were the next test subjects, and the results were the same as the findings with the mice. Rabbits and later cats were tested, again the results were the same as with the mice. These

experiments are facts of the results of actual controlled experiments and are not theories or ideas. Anyone wishing to do so can reproduce these experiments.

Can we now program man to be more physical or mental, depending on the need of society? Based on our findings from these early experiments, we believe man can be conditioned in a like manner and his life expectancy extended far beyond what is now considered to be his three score and ten years.

Remembering that these tests were conducted on the entire body of the animal, could we by placing the North pole of a magnet directly at the center of the brain of larger animals and voluntary human subjects raise the intelligence and sensitivity?

Comments about claimed findings from TGD point of view

If true, these findings provide a direct evidence for the notion of magnetic body (MB) central in TGD inspired theory of consciousness and quantum biology. MB would use biological body as a motor instrument and sensory receptor and serves as an intentional agent. One could understand the findings as being due the loss of the control of the behavior performed by magnetic body as the south directed magnetic field is added. North directed magnetic field seems to have opposite effect.

The fields used are rather strong: the strength is 2 Tesla, by a factor of 10,000 stronger than the endogenous magnetic field $B_{end} = .2$ Gauss playing key role in TGD based quantum biology. This field has been assumed to define lower bound for the endogenous magnetic field strengths but it seems that also weak field strengths are possible down to the values where cyclotron energies of dark photons are proportional to \hbar_{eff} which in turn is proportional to the mass of the charged particles (so that cyclotron energies do not depend on mass of the charged particle and are universal) become smaller than thermal energy at physiological temperature.

1. Paramagnetic effect as strengthening of the coupling between MB and biological body?

The explanation for the effects could be that paramagnetic effect occurs and depending on the direction of the applied field increases or reduces the coupling of brain to Schumann resonances. The MB of the water and thus of living organisms and of their parts are indeed proposed to entrain with the Schumann resonances of the Earth's magnetic field by resonance coupling. These frequencies would be crucial for the control of biological body by MB.

Why the direction of external magnetic field does affect the situation? Brain contains magnetic molecules organised in the direction of Earth's magnetic field. The external field would tend increase or reduce the strength of these dipoles and the effect would be enhanced/reduced coupling to Schumann resonances for north/south directed external field. This would strengthen/weaken the communications/control by MB - the higher level intentional agent- and lead to the observed effects.

It makes sense to recall what was already said about Schumann resonances. The frequencies of Schumann resonances correspond to EEG resonance frequencies. Callahan found that in the regions, where Schumann resonances are weak, there is a lot of social disorder so that Schumann resonances seem to be essential also for collective consciousness and well-being. Callahan also found that plants growth faster if the soil is paramagnetic.

2. The function of magnetite and other magnetic molecules in brain?

The function of magnetic molecules (magnetite Fe_3O_4 mostly) in brain (see <http://tinyurl.com/ybprw4s>) has remained somewhat a mystery. Very probably they help to navigate but the function might be much deeper. Could magnetic molecules help to build a stronger connection to the magnetosphere and magnetic body - could one say that they serve the role of antenna? This would be directly visible in EEG for instance. Resonances would be stronger and communications to and control by MB would be more effective.

Wikipedia article about magnetite(see <http://tinyurl.com/jxl9tk9>) tells also about the role of magnetite in brain. The text below contains also my comments.

1. Living organisms can produce magnetite. In humans, magnetite can be found in various parts of the brain including the frontal, parietal, occipital, and temporal lobes, brainstem, cerebellum and basal ganglia. Iron can be found in three forms in the brain – magnetite,

hemoglobin (blood) and ferritin (protein), and areas of the brain related to motor function generally contain more iron. Magnetite can be found in the hippocampus associated with information processing, specifically learning and memory.

Comment: If magnetite would serve only for navigation, it would be probably appear only in some special part(s) of brain.

2. Hemoglobin and ferritin contain iron. Hemoglobin is however only weakly paramagnetic whereas ferritin (protein!) nanoparticles can be *superparamagnetic* (see <http://tinyurl.com/y796kc4y>).

Comment: What puts bells ringing is that Callahan found the addition of paramagnetic substances in soil to be beneficial for the plant growth by Callahan.

3. Magnetite can have toxic effects due to its charge or magnetic nature and its involvement in oxidative stress or the production of free radicals. Research suggests that beta-amyloid plaques and tau proteins associated with neurodegenerative disease (Alzheimer) frequently occur after oxidative stress and the build-up of iron.

Comment: But could the higher level of paramagnetic iron be the reason for Alzheimer or is it due to attempt of brain to improve coupling to Schumann resonances and overcome the effects of Alzheimer? Same question has been made also concerning the plaques in axons emerging in Alzheimer [J36] (for the TGD based model for Alzheimer [L52] see <http://tinyurl.com/ybq6r3xu>).

3. Magnetic healing at the level of organisms and social structures?

Could one consider artificial strengthening of the brain coupling to Schumann resonances as magnetic healing of not only biological but also social disorders? Could one just add magnetic molecules to brain? One cannot exclude this kind of possibility and it might be possible to test this with animals.

Many of us are well aware about the worsening situation in our society governed by market economy. Many researchers speak even about a possible collapse of our civilization. Also the strength of the magnetic field of Earth is weakening with a rate of 5 per cent per century (see <http://tinyurl.com/ybbw4lue>). Is this mere accident? It would be interesting to see whether something similar has happened for the local magnetic field during the collapses of the earlier civilizations. If there is a connection, could one imagine improving the situation by magnetic healing?

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Chapter 8

Macroscopic Quantum Coherence and Quantum Metabolism as Different Sides of the Same Coin: Part I

8.1 Introduction

TGD inspired theory of consciousness and the ideas about quantum control allow already now a rather detailed view about conscious brain. There are general theories for qualia, sensory representations, and quantum control based on many-sheeted ionic flow equilibrium. p-Adic space-time sheets serve as correlates for cognitive representations and recently adelic vision has allow to understand imagination in terms of p-adic pseudo constants [K80].

The role of metabolism for quantum consciousness has however remained poorly understood hitherto. There are also other white regions in the map. How motor control is realized: directly from brain level or from magnetic body as the computer sitting at its own terminal metaphor would suggest? And what is the deeper quantum meaning of neurotransmitters and hormones, and so called information molecules in general? If they were only inhibitors, excitators, and modulators, the organisms would not bother to construct so many different information molecules.

The quite recent steps of progress (I am writing this 2015) has finally allowed to a rather detailed answers to these questions.

Before continuing I wish to thank for many people for providing very important stimuli: in fact, the strange synchronies encourage me to think that we all might belong to a greater pattern gradually becoming self-conscious. I would like to mention Lian Sidorov for turning my attention to remote mental actions and bio-photons and for very stimulating discussions and questions. Also the contact by finnish new energy enthusiasts Juha Hartikka, Jukka Kinnunen and Tapio Tammi, came just in right time to allow to realize the connection with some new physics phenomena suggested by new energy technologies. The material sent for year or two ago by Gene Johnson related to brain metabolism turned also to be very invaluable. I do not know who I should thank for the existence of web: without the availability of information about practically anything between Earth and Heaven this kind of convergence of ideas would be completely out of question. Without the encouragement and financial support from Tommi Ullgren I could not have been able to continue my work.

8.1.1 Dark Matter Hierarchy, Sensory Representations, Motor Action, And Metabolism

Dark matter hierarchy forces a profound reconsideration of brain metabolism and allows to develop a detailed model for how magnetic bodies use biological bodies as sensory receptors and motor instruments [K44] leading among other things to a generalization of the notion of genome.

For ordinary quantum mechanics photons at EEG frequencies correspond to ridiculously small energies. Dark matter hierarchy is accompanied by a hierarchy of EEGs and its generalizations with the scalings of frequencies predicted to come in multiples of integer in the most general case. A strong hypothesis is that they come as powers $r = 2^{k_d}$, where the values of k_d are fixed by Mersenne hypothesis [K44].

The fact that arbitrarily small frequencies can correspond to energies above thermal threshold at higher levels of dark matter hierarchy implies that photons with arbitrarily low frequencies can have sizeable physical effects on matter. This conforms with the findings about the effects of ELF em fields on living matter [K44]. and these effects allow to develop a rather detailed model for EEG and identify the parts of EEG correlating with communications of sensory data to the magnetic body and with quantum control performed by the magnetic body [K44].

The implication is that the transfer of energy between magnetic bodies and biological body could be major factor in metabolism. The question is whether the magnetic bodies provide metabolic energy for brain or utilize the metabolic energy provided by brain or both. Time mirror mechanism as a mechanism of intentional action would predict that magnetic body uses the metabolic resources of brain during intentional action. Together with the strange findings about ionic currents through cell membrane suggesting that ionic channels and pumps are actually ionic receptors and the ionic currents through them are only small samples about the net currents, this vision leads to a profoundly new view about brain metabolism. Dark matter hierarchy forces a profound reconsideration of brain metabolism and allows to develop a detailed model for how magnetic bodies use biological bodies as sensory receptors and motor instruments [K44] leading among other things to a generalization of the notion of genome.

The reduction of the hierarchy of Planck constants to a hierarchy of quantum criticalities was already mentioned and finally provides a great vision allowing to ask questions beginning with "Why".

8.1.2 New Ideas

After the writing of the first version of this chapter for about decade ago several new ideas have emerged and the challenge is to unify these ideas.

Three different views about living matter as a macroscopic quantum system

There are three different views about how living system manages to be a macroscopic quantum system.

1. The first vision is based on various kinds of super-conductivities [K23]. Electronic super-conductivity is assigned with the cell membrane and plays a key role in the model of cell membrane as a Josephson junction. Furthermore, the effects of ELF em fields on vertebrate brain [K44] suggest that biologically important ions form macroscopic quantum states and cyclotron Bose-Einstein condensates of bosonic ions have been suggested. The TGD based view about atomic nuclei predicts exotic nuclei chemically equivalent with ordinary ones but being bosons rather than fermions. Also these exotic ions could also form cyclotron Bose-Einstein condensates. Large value of Planck constant would guarantee that cyclotron energies proportional to \hbar are above thermal energy.
2. A more precise view about hierarchy of Planck constants as an implication of the enormous vacuum degeneracy of Kähler action has emerged [K47]. According to this view non-standard values of Planck constant are only effective.

As the idea about the hierarchy of Planck constants emerged, I proposed that favored values of Planck constant could come as powers of 2^{11} . This was just a first guess inspired partially by the observation that the mass ratio of proton and electron is $940/.5 = 1880 \sim 2^{11}$. I managed to find indications supporting this hierarchy and also this chapter contains traces of this idea. I became later skeptic but one could actually imagine a mechanism implying this kind of hierarchy. Dark protons with say $r = \hbar/\hbar_0 = 1836 = 4 \times 3^3 \times 17$ would correspond to approximately same Compton length as ordinary electrons. It is natural to assign this value of \hbar also to electrons and this gives Compton length 44.6 Angstroms not far from the p-adic length scale $L(149) \simeq 50$ Angstroms assigned with the lipid layer of cell membrane.

The condition that dark proton corresponds to this Compton length gives $r = 1836^2$: the electron Compton length comes now $8.1 \mu\text{m}$, which corresponds to cell size scale. One could continue the resulting hierarchy of Planck constants indefinitely.

3. The notion of negentropic entanglement making sense for rational and even algebraic entanglement probabilities has emerged as a possible characterizer of living matter [K73]. Quantum arithmetics [K84] allows to generalize the notion of rational so that p-adic real correspondence mediated by canonical identification is fixed uniquely and is both continuous and respects symmetries [K84]. One implication is an explanation for Shnoll effect [K8], which could be important also in living matter.

This raises several questions.

1. How high T_c super conductivity based on dark electron pairs and negentropic entanglement relate?
2. Could it be that electron pairs in valence bonds are the carriers of negentropic entanglement (see **Fig.** <http://tgdtheory.fi/appfigures/cat.jpg> or **Fig.** 21 in the appendix of this book) and that they generate the magnetic flux tubes as parts of their magnetic bodies? This makes sense only if the valence electron pairs in living matter have spin 1. The Cooper pairs of high T_c super-conductors are indeed known to have spin 1 [?] If this view is correct, biological evolution would favor the maximization of covalent electron pairs and this indeed seems to be the case.
3. Why large \hbar would make possible negentropic entanglement or even force it? Is there some purely number theoretic reason for this?

The progress has occurred in several frontiers.

The most recent progress

The progress which has taken place during period 2014-2015 has led to a dramatic increase of understanding concerning ZEO [K77], NMP [K73], hierarchy of Planck constants and dark matter [K36, K37, K38, K39], the notion of self [K80, K103], and p-adic physics as physics of cognition [K80].

1. Weak form of NMP [K73] and ZEO based view about state function reduction has led to the detailed identification of self as a sequence of state function reductions at same boundary of CD (Zeno effect) [K10, K136] and led to the identification of sensory-motor cycle and its generalizations as a kind of Karma's cycle in which subselves representing mental image die and re-incarnate as time reversals at the opposite boundary of corresponding CD. The death of sensory mental image means generation of motor mental image or vice versa. The predicted existence of time reversed mental images serves as a test for the theory [K80].
2. Hierarchy of Planck constants has been assigned with a hierarchy of quantum criticalities, and phase transitions increasing \hbar_{eff} and negentropy take place spontaneously as self dies and re-incarnates as time reversed mental image in the first reduction to the opposite boundary of CD [K36, K37, K38, K39, K73]. Although the death of self is like picking fruit from tree (NE is generated), selves do not want to die and in order to satisfy the demands of NMP must generate negentropy by refining their mental images by in their respective Karma's cycles. Conscious entities can also steal negentropic entanglement by eating other conscious entities. A more neutral manner to express is to talk about metabolism, which can be energy metabolism but also other kinds of metabolisms providing the system with negentropy. This view about metabolism emerged already earlier [K88] but only the precise formulation of the notion using ZEO, weak form of NMP, and the vision about hierarchy of quantum criticalities allowed the detailed understanding.

This framework allows even to consider answers to questions about origin of ethics and moral [K136].

3. Also the understanding of p-adic physics as physics as physics of cognition has developed dramatically with the advent of adelic vision about TGD in which all number fields appear democratically. Together with the understanding of strong form of holography stating that string world sheets and partonic 2-surfaces (briefly 2-surfaces) serve as space-time genes this leads to a beautiful view about how number theoretical universality is realized by algebraic continuation of the 2-surfaces to space-time surfaces. One can even understand imagination in this framework: pure imagination not realizable in real world corresponds to collections of 2-surfaces continuable to p-adic space-time surface (pseudo constants make this possible) but not to real space-time surfaces.

Genetic code and dark nucleon states

New realization of the genetic code in terms of dark proton sequences identified as dark nucleons was discovered [L3, K58].

1. The states of dark proton are in natural one-one correspondence with DNA, RNA, tRNA, and amino-acids and vertebrate genetic code is realized in a natural manner. Dark nucleons realized DNA codons as entangled quark triplets. The effective chemical formula $H_{1.5}O$ for water in atto-second time scale supports this view [K43]. How the notion of dark nucleon relates to negentropic entanglement of electrons? Could dark electron pairs and dark nucleons correspond to the same value of Planck constant? Could both dark protons and dark electrons play a key role in metabolism.
2. The simplest guess is that DNA strands are accompanied by dark nuclei with one dark proton per DNA nucleotide. The resulting positive charged would stabilize the system by partially neutralizing the negative charge density due to the phosphorylation (2 negative charges per nucleotide). Dark proton sequences could be associated also with other important bio-polymers. If the spins of the dark protons are parallel the dipole magnetic fields give rise to flux tubes connecting the protons and one can assign to the large \hbar protons a macroscopically quantum coherent phase.
3. The natural guess would be that dark nucleus realization of the genetic code induces the biological realization as evolution assigns to dark nucleon sequences DNA, RNA, and amino-acid sequences with 1-1 correlation between dark nucleon state and basic unit of the sequence. The dark realization of genetic code suggest a totally new view about biological evolution as a process, which is analogous to R&D in high tech industry rather than being completely random [K58]. The candidates for new genes could be tested at dark matter level and in the case that they work they would be transcribed to their chemical equivalents.

New ideas related to metabolism

Also new ideas related to metabolism have emerged at the same time when evidence for quantal aspects of photosynthesis has been emerging [I118, I43, I40, I18].

1. Negentropic entanglement (NE) leads also to the idea about energy metabolism and negentropy transfer as different sides of the same coin. The model for DNA as topological in turn suggest that $ADP \rightarrow ATP$ and its reverse can be interpreted as a standardized reconnection process re-organizing connections between distant molecules connected by magnetic flux tubes by the relay defined by ATP molecule. Metabolic energy would - or at least could - go to the re-organization of the flux tube connections and therefore of the negentropic quantum entanglement. The question is how to fuse this vision with the hypothesis about metabolic currencies as differences of zero point kinetic energies for space-time sheets.
2. The radiation from Sun defines the fundamental metabolic currency. Solar radiation cannot be said to negentropic since negentropic entanglement is a 2-particle property. Solar photons could possess a large value of \hbar or - more plausibly - suffer at the magnetic body of the living system a phase transition increasing the value of \hbar . Could the absorption of large \hbar photons arriving from Sun or from magnetic body by electrons generate spin 1 valence electron pairs or provide the metabolic energy needed to re-arrange the flux tube connections between distant molecules by $ADP + P_i \rightarrow ATP$ process?

The identification of $h_{eff} = n \times h$ with gravitational Planck constant $\hbar_{gr} = GMm/v_0$, where v_0 has dimensions of velocity is highly attractive, and in the case of dark cyclotron radiation implies that the cyclotron frequency spectrum is universal and does not depend on the mass of the particle with mass m . This suggests the identification of the ordinary photons resulting from these photons by h_{eff} changing phase transition as bio-photons with energy spectrum in visible and UV (and thus in the region of molecular transition frequencies) [K17]. This would provide for the magnetic body the fundamental control and communication mechanism and the long sought for connection with bio-chemistry. Quantum gravitational coherence would play fundamental role in living matter: not that the gravitational Compton lengths of particles are given by $\lambda_{gr} = GM/v_0$ and are universal.

The latest step of progress has been already mentioned. One can understand how the weak form of NMP forces metabolism as a way for self to stay alive (something rather trivial to understand in the context of everyday life but far from trivial when one can explain it using only the concepts of physics, even allowing some new physics!). Also homeostasis can be seen as a collection of mechanisms making possible for self to stay at given level of quantum criticality: living systems are dancers on the rope!

Living systems need NE but in what form they get it? This is still poorly understood question.

1. NE could effectively reduce to single particle property and be between parts of nutrient molecules. The somewhat poorly understood high energy phosphate bond is a good candidate in this respect. Even elementary particles consisting of pairs of wormhole contacts connected by magnetic flux tube and strings could carry quite an impressive entanglement negentropy characterized by the p-adic prime labelling the particle. For instance, electron would carry almost 127 bits of entanglement negentropy [K80, K28]. For the neutrinos this negentropy would be even higher, and this forces to reconsider the old idea about cognitive neutrinos as carriers of information. For this option NE would be kind of information carrying substance.
2. NE could be between the particle (of nutrient molecule) and large gravitational dark mass M_D and assignable to the flux tubes connecting the particle with this dark mass and assignable to flux tubes connecting particle to the dark mass M_D . This leads to a beautiful model for bio-photons as dark cyclotron photons and predicts for them universal energy spectrum in the range of energies for molecular transitions.

This would make possible large $h_{eff} = \hbar_{gr}$ [K88, K36, K37, K38, K39]. One could even speak of dark gravitational Mother Gaia. For this option NE would be relationship to dark gravitational Mother Gaia and the transfer of NE would be transfer of the other end of flux tube contact to MG.

There are two separate anomalies in the solar system supporting the existence of a spherical layer consisting of dark mass and with radius equal to the distance of Moon from Earth [K111]. The first anomaly is so called Flyby anomaly and second one involves a periodic variation of both the value of the measured Newton's constant at the surface of Earth and of the length of the day. The period is about 6 years and TGD predicts it correctly.

3. Both options might well make sense but it is still an open question whether one should select between them or not. It might be also possible to transform long length scale NE to short scale NE by splitting from U-shaped flux tube pairs carrying long range NE short flux tube pairs by reconnection and carrying NE in short scale.

DNA as a topological quantum computer vision

The vision about DNA as topological quantum computer [K3] has turned out to be very general allowing to imagine several concrete realizations. The essential element is the coding of DNA nucleotides and one can imagine several options.

1. The original proposal for the realization of DNA as TQC is based on the representation of DNA nucleotides A, T, C, G as quarks u, d and their antiquarks and requires scaled up version of QCD [K3]. This idea looks rather outlandish but could be justified by the strange findings of mathematician Barbara Shipman about honeybee dance [A6] and also by the p-adic length

scale hierarchy and the hierarchy of Planck constants suggesting scaled variants of QCD like physics also in the length scale range relevant to the living cell.

2. The question whether one could use spin 1 triplet and spin 0 singlet of dark electron pair instead of quarks and their antiquarks to represent codons, is rather obvious. The problem is that $S = 0$ state for electron pair however gives rise to vanishing dipole field so that flux tube structure would not be possible. The generation of flux tube structure along which supra currents can flow is however an essential element of the proposed mechanism of super-conductivity.
3. DNA as topological quantum computer hypothesis lead to the hypothesis that it is $O=$: s to which one must assign the flux tube pair responsible for the representation of the genetic code. Why $O=$ would be in special role? And why should one have a pair of flux tubes? Could this relate to the coding of nucleotides by electron pairs? If there are two parallel flux tubes, one obtains tensor product $3 \times 3 = 5 + 3 + 1$ of electron triplets at the ends of the flux tubes. Could it be that A, T, C, and G are represented in terms of 3 and 1 and that the breaking of rotational invariance implies mixing of singlet and $S_z = 0$ state of triplet so that nucleotides and their conjugates could correspond to the resulting two pairs related by reflection.
4. $ATP \rightarrow ADP + P_i$ would correspond to the reconnection of the flux tubes of the flux tube pair with hydrogen bonds associated with two water molecules. The flux tubes would split and end to water molecules containing valence electron pair so the negentropic entanglement might not be totally lost. The reverse process would create flux tube connection labelled by the spin state equivalent of A, T, C, or G.

What happens to the second law of thermodynamics?

The possibility of negentropic entanglement raises the question about the fate of the second law of thermodynamics. I have already earlier considered a maximally pessimistic generalization of second law but it now clear that it does not rest on a sound basis.

Apparently NMP states just the opposite of second law. This is not the case however since NMP is about entanglement negentropy and second law about ensemble entropy. It is however easy to imagine that the generation of NE in thermal ensemble breaks second law. This process however generates dark matter, and if one limits second law to processes in with permanent generation of dark matter does not occur, second law should hold true.

Concerning life second law and NMP are diametrical opposites of each other. In the world governed by second law alone life is thermodynamical fluctuation. In the world governed by NMP life is unavoidable since quantum criticality is reduced gradually but weak form of NMP allows the analogs of thermodynamical fluctuations in which negentropy does not increase. Weak form of NMP however allows also negentropy gains larger than those allowed by strong form of NMP.

8.1.3 Many-Sheeted Photosynthesis

Photosynthesis is a fundamental metabolic function and a many-sheeted model allows to concretize the general ideas about quantum metabolism. What happens in photosynthesis at the level of energy balance seems to be relatively well-understood [I57, I38] but the detailed molecular mechanisms remain obscure. Several strange features, such as the appearance of electron pairs, suggest that super-conductivity and atomic and molecular Bose-Einstein condensates are involved. p-Adic length scale hypothesis gives very strong quantitative guidelines in the attempt to understand photosynthesis in many-sheeted space-time, and one ends up to a general view about how Bose-Einstein condensates store metabolic energy as zero point kinetic energy and how this energy is utilized by remote metabolism by generating negative energy MEs. What is so remarkable is that the resulting simple model of photosynthesis is successful both at qualitative and quantitative level.

I have included in this chapter the earlier variant of the quantum model developed before 2007 as such to compare it with the recent view about macroscopic quantum aspects of photosynthesis involving several new ideas. Note that year 2007 is special in the sense that during 2007

the first evidence for the quantal nature of photosynthesis emerged. 2015 is the year of the most recent updating. imoleph

The appendix of the book gives a summary about basic concepts of TGD with illustrations. Pdf representation of same files serving as a kind of glossary can be found at <http://tgdtheory.fi/tgdglossary.pdf> [L21].

8.2 General View About Sensory Representations, Motor Control, And Metabolism

The following summarizes the general after dark matter revolution vision about sensory representations, motor control, and brain metabolism.

8.2.1 General Vision About Living Matter As A Macroscopic Quantum System

The assumptions below summarize the general vision achieved before the dark matter revolution. The picture is consistent with the findings of Libet about strange time delays of consciousness [J65, J23] discussed in the article “Time, Space-time and Consciousness” in [L2] and chapter [?].

1. Magnetic bodies forming a hierarchy are the fundamental volitional agents transforming intentions to actions. Intentions are represented by p-adic MEs transformed to negative energy MEs representing the desire about particular activity communicated to the lower level magnetic bodies in the geometric past and eventually to the material body. Each negative energy ME in the cascade represents a desire to realize some submodule in motor program. Eventually the cascade of negative energy MEs ends up to the glial cells serving as metabolic sources. The desired action is generated in terms of neural communications and of positive energy MEs both representing classical communications to the geometric future. The desire in question could be a desire to perform a particular motor action, a desire to direct attention or select among sensory percepts (binocular rivalry [K80] is the standard example), or a desire to remember something. Sensory perception, motor action, and memory would thus be based on essentially the same basic mechanism. The population inverted many-sheeted laser system providing the energy source in brain or body would consist of bosonic ions or of Cooper pairs of fermionic ions in excited cyclotron states.
2. Sensory representations are realized at the magnetic bodies associated with the sensory organs and sensory mental images are shared with the personal magnetic body by negative energy em MEs. Brain constructs only symbolic and cognitive representations, writes the sensory music to notes. The mental images defined by these representations can be shared by personal magnetic body or magnetic bodies associated with the sensory organs in a similar manner. Also classical communications to the personal magnetic body are possible. A tree like structure with the root represented by sensory mental images and branches and leaves represented by various symbolic and cognitive mental images results.

The selective entanglement by negative energy MEs allows to understand the active aspects of sensory experience involving direction of attention and selection between percepts at various levels. In the case of motor actions, the negative energy MEs received from magnetic body communicate the desires of the magnetic bodies about motor actions to be performed and the response by positive energy MEs would realize these desires as nerve pulse patterns.

3. Positive energy interior MEs lie along interior of magnetic flux tubes of the personal magnetic body. These MEs could relate to the classical communication of the symbolic representations constructed from the data processed in the brain to the magnetic body. Sensory perception and memory differ only is that the time scale involved is different. Declarative memory corresponds to negative energy MEs sent from a point of the personal magnetic body at the distance $L = cT$ to the material body and reflected back as positive energy MEs. Thus the material body serves as the mirror unlike in the original variant of the mirror mechanism of memory. The distance $L = cT$ along magnetic flux proportional to the transverse area

S of the flux tube $L \propto S$ tubes codes for the temporal distance to the geometric past by transforming it to cyclotron frequency scale.

8.2.2 A General View About Quantum Control, Coordination And Communication Inspired By Dark Matter Hierarchy

The general vision about motor action is roughly the following. The dark matter hierarchy with levels labelled by the increasing values of Planck constant defines a hierarchy of intentional agents. The original vision was that intentions are realized as p-adic space-time sheets transformed to real ones as intention is transformed to desire.

This view have been modified since the phase transition between different number fields is not a mathematically sound notion, and it is better to talk about imagination. The starting point is strong holography allowing to continue string world sheets and partonic 2-surfaces parametrized by numbers in an algebraic extension of rationals (briefly 2-surfaces) to space-time surfaces and code the physics using the data at the 2-surfaces. Algebraic universality is achieved by algebraic continuation to various number fields.

Pure imagination as non-realizable imagination corresponds to 2-surfaces continuable to p-adic space-time surfaces (p-adic pseudo constants) but not allowing a continuation to real space-time surface. In state function reduction to the opposite boundary of CD state function reduction selects the 2-surfaces, which allow a continuation to real space-time surfaces. This corresponds to a realization of intention as action. During state function reduction sequences at the same boundary super position of 2-surfaces receive contributions, which can correspond also to pure imagination. One could perhaps interpret this as a development of intentions. Sensory perception and motor action are time reversals of each other.

Negative energy MEs serving as space-time correlates for dark photons and also dark variants weak bosons and gluons are good candidates for the representations of these desires. A natural guess is that the desires are communicated from given level of dark matter to the next level below it and ultimately the level of ordinary matter represented by the biological body is reached and the signal induces various neural and other activities realizing the desired motor actions. Each level has a lot of freedom to decide about the details of that part of motor action for which it is responsible.

Motor action is an iterative top-down process, a gradual build-up of a four-dimensional space-time statue representing the motor action starting from a rough sketch and adding gradually the details. This view is consistent with how we experience motor control: what happens is that we decide to move hand, rather than initiating consciously some complex neuronal activity in brain leading to the raising of the hand. We need not know how the motor action happens in order to initiate it.

The control signals from the magnetic body must enter to structures with high connectivity and very probably be very simple and symbolic. A reference wave generating complex hologram would be an over-simplified example about an initiator of a complex control action proceeding gradually to the lower levels of hierarchy by similar simple signals. Of course, some linguistic structure based on, say, amplitude modulation is required to avoid interference of the undesired signals with the bio-control. Various gap junction connected structures are a good guess for the relay stations the control commands from the magnetic bodies. Thus gap junction connected neuron groups, astrocytes, and the walls of arteries and perhaps even capillaries are good candidates for receivers at the level of brain. At the level of body various organs, epithelial tissues, walls of arteries, and also skin could be the mediators of the generalized motor actions during sleep.

Dark matter hierarchy and motor control

The following general overview about quantum communication and control emerges from the model for EEG hierarchy as correlate for dark matter hierarchy discussed in detail in [K44], and from the implications of the model of DNA as topological quantum computer [K3, ?, K7]. Consider first general assumptions about how motor actions would be controlled from magnetic body.

1. Massless extremals (MEs, topological light rays) serve as correlates for coherent states and Bose-Einstein condensates of dark bosons. Neutral massless extremals could be responsible

for signals related to control, coordination and communication. Also charged and colored MEs are predicted but their role has not yet been firmly established. Negative energy MEs would be related to motor control and positive energy MEs to communication of sensory data. Zero energy ontology, which has become the cornerstone of quantum TGD [K31, K30], justifies the notion of negative energy ME.

2. Magnetic body has an onion like hierarchical structure and its layers receive sensory information from biological body and perform motor control. The matter at the layers of magnetic body corresponds to the value of Planck constant which is so large that cyclotron energies are above thermal energy. A fractal hierarchy of analogs of EEG is involved with these communications. The frequencies involved correspond to harmonics of cyclotron frequencies for biologically important ions and to differences and sums of these with Josephson frequencies associated with Josephson junctions defined by the magnetic flux tubes carrying dark supra currents. Magnetic flux tube refers in the following to ordinary or “wormhole” magnetic flux tube since it is not yet clear which of them of these options if not both are realized [K3]. Flux tubes bind the biological molecules to a weblike structure and are responsible for the macroscopic quantum coherence of living matter.
3. Negative energy control signals from the magnetic body initiate topological quantum computation like processes whose outcome is expressed as four-dimensional self-organization patterns relying basically on gene transcription inducing motor responses in a very general sense. It is also possible that the outcome is expressed as an electromagnetic signal generated by intronic portion of the DNA representing a call of TQC subprogram. The experimental work of Peter Gariaev suggests that polarization coding of DNA sequences is involved with the sub-program calls and TGD provides a model for how this could take place [K3].
4. Harmonics of cyclotron frequencies relate to the control of the biological body by the magnetic body and could be assigned with the magnetic flux sheets going through DNA since it is genome where protein synthesis is initiated and is thus the optimal intermediate step in the cellular control. Differences and sums of harmonics of cyclotron frequencies and Josephson frequencies would be involved with communication of sensory data.
5. One of the basic functions of cell membranes is to perceive the chemical environment using various kinds of receptors as sensors. Neurons have specialized to receive symbolic representations of the sensory data of primary sensory organs about the situation in the external world. A good guess is that in this case magnetic flux quanta are hollow cylindrical structures parallel to the cell membrane associated proteins serving as Josephson junctions. Also magnetic flux tubes parallel to axon serving as templates for axons could define communication lines connecting cell membranes to the cellular magnetic body. Also synaptic contacts should involve similar magnetic flux quanta connecting them to neuronal magnetic body.
6. In DNA as topological quantum computer vision magnetic flux tubes as carriers of supra currents of dark variants of charged particles and connecting cell interior and exterior define braid strands. The quantum phase transitions changing the value of Planck constant and thus length of flux tubes would be fundamental building element bio-control in the scale of biological body and involved with both bio-catalysis and higher biological functions at nanoscale (molecular motors) and in the scale of cells and organs.
7. This picture would explain why the temperature of brain must be in the narrow range 36-37 K to guarantee optimal functionality of the organism [K44]. If interior superconductivity is lost, magnetic body receives sensory data but is paralyzed since its desires cannot be realized. If boundary superconductivity is lost, magnetic body can move but is blind.

There are also additional hypothesis which are natural in TGD framework but whose necessity is not yet clear.

1. In the length scales below the weak length scale L_w also charged weak bosons behave as massless particles and the exchange of virtual W bosons makes in principle possible a non-local charge transfer. Dark quark-antiquark pairs associated with the color bonds of the

atomic nuclei can become charged via the emission of dark W boson and thus produce and exotic ion. The same can happen at the higher levels of dark matter hierarchy.

2. Besides neutral massless extremals (MEs) TGD predicts also charged MEs obtained from their neutral counterparts by a mere color rotation (color and weak quantum numbers are not totally independent in TGD framework). W ME would represent an exchange of virtual W boson giving rise to em current. Charged massless extremals could be seen as correlates for non-local quantum control by affecting charge equilibria whereas neutral MEs would serve as correlates for coordination and communication. Color charged MEs could also induce color charge polarization and flows of color charges and thus generate visual color qualia by the capacitor mechanism discussed in [K54]. The exchange of W bosons appears in an active role in TGD inspired model [L3], [L3] of cold fusion, biofusion [C2], and plasma electrolysis [D43]. The exchange of exotic W : s between nuclei would give rise to exotic nuclei. For instance, chemically equivalent bosonic counterparts of biological important fermionic ions such as Na^+ , K^+ , Cl^- could be generated and could form Bose-Einstein cyclotron condensates at magnetic flux tubes. Whether biologically important ions can have exotic nuclei having mass number differing from expected could be easily tested.
3. The second non-local quantum control mechanism relies on em charge entanglement. Charge entanglement could involve a superposition of pairs ordinary ions/atoms and exotic ions connected by a W massless extremal joining magnetic body and biological body. In quantum jump this state would be reduced to exotic charge state with some probability increasing with the strength of the classical W field. The successful proposal for the protein folding code relying on the assumption that wobble base pairing corresponds to charge entanglement between quark and antiquark (superposition of uu_c and dd_c pairs forming a pion like state) at the ends of the magnetic flux tube connecting tRNA with $N - H$ group of amino-acid backbone [K7].
4. These non-local quantal mechanisms can induce or change electromagnetic polarization in turn inducing ordinary charge flows and in this manner make possible quantum control of nervous system by magnetic body. The generation of nerve pulse could rely on the spontaneous state function reduction occurring for charge entangled state reducing the resting potential below the critical value by this kind of mechanism inducing charge transfer between cell interior and exterior and inducing voltage pulse generating DC supra current [K96]. Also remote mental interactions, in particular telekinesis, might rely on this mechanism. Of course, the interactions between magnetic body and biological body are essentially remote mental interactions.

In the introduction the latest progress in relating hierarchy of Planck constants to a hierarchy of quantum criticalities has been mentioned [K140, K36, K37, K38, K39] and its biological meaning was discussed.

What conditions the sensory projectors to the magnetic body must satisfy?

General constraints for a rather detailed and testable models for the hierarchy of sensory canvases (magnetic bodies) and for the system projecting sensory data to it. An especially important new element is the model for the generation of ELF MEs acting as sensory projectors.

The projectors to the sensory canvas should satisfy several constraints.

1. Sensory projectors should correspond to magnetic flux quantum structures (tubes or sheets). The magnetic flux tube structures would be to those of Earth's magnetic field plus possibly those generated by the magnetic structures and would have fixed directions by anchoring to the large scale Earth's magnetic field.
2. Projectors must be able to bind neurally represented features to the point of the sensory canvas they project. Binding would be achieved the magnetic flux quanta traverse through synaptic contacts of a larger number of firing neurons.

3. There must exist a fixed frame of reference which does not rotate when head or body rotates or moves in the scale of magnetic body much larger than the corresponding body part. The directions of Earth's magnetic and gravitational fields fix naturally this kind of reference frame. Red blood cells and pyramidal cells are magnetic structures and define naturally compass needles allowing to construct sensory representation providing information about the orientation and configuration of the body with respect to this preferred coordinate frame.
4. The fundamental exterior-interior division of the sensory experience to the bodily sensations and percepts about external world or body as seen by external observer should correspond to fundamentally different sensory representations. Blood-brain barrier is an excellent candidate for the representation of this separation at the level of brain. Neuronal consciousness would represent outsider's cognitive view about the external world and body whereas blood consciousness would represent insider's view about body.

Astrocytes define the analog of a skeleton for neurons having endfeet to the synaptic contacts and might play key role in the binding. Hence astrocytes might act as higher level sensory organs integrating the sensory input of synchronously firing neuron groups. The myelination of axons by oligodendrites is usually regarded merely as an insulation allowing to achieve rapid neuronal communications through long distances. Myelin sheaths could also serve as sensory receptors scanning for nerve pulse activity along axon.

Communications and energy transfer at cellular level

The communication and energy transfer at cellular level could rely on Bose-Einstein condensed and coherent photons at the lowest level of dark matter hierarchy. MEs defining single sheeted covering of M^4 with lengths given by typical distance between red blood cells and ordinary cells would define the space-time correlates for these photons. The wavelength range involved would cover visible wave lengths so that the identification as bio-photons [K21], [I107] might make sense.

At higher levels of the dark matter hierarchy MEs would have $r = \hbar/\hbar_0 = 2^{k_d}$ if Mersenne hypothesis holds true. Each of them would carry the energy $E = \hbar_0\omega$ of a visible photon, so that the relationship $E_k = \hbar(k)\omega = r\hbar_0\omega$ would have a space-time correlate. Their decay to ordinary photons by de-coherence would produce r ordinary photons. This would make possible coherent liberation of large amounts of energy and momentum.

Besides chemical signalling genuine quantum communication based on bound state entanglement between red blood cell colony and neurons can be considered. Charged entanglement induced by W MEs is one option and state function reduction of this entanglement inducing deviation from charge equilibrium could induce Ca^{++} waves just as it would induce nerve pulses. The blood cell colony, the activated synchronically firing group of neurons, and astrocytes could entangle to form single quantum system and communication would be a cellular variant of telepathy. The entanglement of the blood cells with the synchronically firing neuron groups could be crucial for the assignment of features represented by neuron groups to the points of the magnetic sensory canvases.

Charged entanglement between magnetic body of some gland and corresponding hormones carried by blood flow represents a possible example of quantum communications. Hormone would be like an old fashioned postman but the letters would contain quantum links to the quantum web. Nerve pulse transmission would be a more modern communication method involving electronic transfer along axons: postman mechanism would be realized only at synaptic contacts. Quantum links could ultimately refer to the primary sensory input at the level of sensory organs so that sensory input would be associated with cognitive mental images produced by the neural activity. Besides carrying the quantum links, neural transmitters would induce neuronal chemical qualia at the synapse.

Emergence of symbols at molecular level and new view about hydrogen bond, water, and bio-catalysts

The hierarchy of dark matter leads to novel ideas about what distinguishes living matter from ordinary matter. The emergence of symbols and symbolic dynamics and what might be called

“molecular sex” could be a fundamental step in the process and I have considered two visions for how this would take place.

1. First vision

First vision is relies on the model of DNA as TQC based on braids and has quite close contact with empirical reality [K13, K3, ?]. In this case DNA nucleotides are analogous to colors of braid strands and base pairing corresponds to molecular sex for DNA molecules. The color of braid strand implies long ranged highly selective interactions between DNA and distant molecules, such as lipids of the lipid layer of cell membrane or amino-acids. Free amino-acids inherit the colors of the first two nucleotides in the codon XYZ whereas the color of the third nucleotide corresponds to a quantum superposition of colors for codons coding for the amino-acid: this defines the quantum counterpart of wobble base pairing. Amino-acids can be divided into amino-acids and their conjugates analogous to opposite sexes and generalized base pairing determines the interactions of the amino-acids to a high degree. Hydrogen bond can be identified as a special case of flux tube. There are also flux tubes connecting acceptors of hydrogen bonds acting as plugs in the connection lines formed by the magnetic flux tubes and Y corresponds to this kind of plug at the level of amino-acids.

In the recent conceptual framdework The molecular sex could indeed interpreted as pairing of n space-time sheet of two n -fold coverings which are singular in the sense that the sheets coincide at the ends of CD. This brings in n discrete degrees of freedom and these degrees of freedom would be central in living matter and give rise to symbolic dynamics almost independent of the material substrate. The n -sheets would be associated with magnetic flux tubes.

One of the implications is a proposal for a code for protein folding [K7]. In the light of afterthought this proposal looks involves possibly un-necessarily strong assumptions - such as the identification of flux tubes in terms of hydrogen bonds - and it would be better to just talk about n -sheeted magnetic flux tubes as basic correlates of attention and avoid too detailed identifications. There is no absolute need to reduce these new degrees of freedom to ordinary biochemistry or vice versa.

With this reservations in mind let us summarize the model.

1. Hydrogen bonds play a key role in bio-catalysis but are not understood completely satisfactorily in the standard chemistry. Hence the basic question is whether hydrogen bonds can be regarded as or are accompanied by short (wormhole) magnetic flux tubes: note that the subject-object asymmetry of directed attention would correspond to donor-acceptor asymmetry of they hydrogen bond. If this is the case, the identification of the magnetic flux tube connection as a generalized hydrogen bond becomes natural. At least the atoms able to form hydrogen bonds could form flux tube contacts so that the model would be very predictive and would conform with the known important role of hydrogen bonds in bio-catalysis.
2. The fact that hydrogen bonds connect base pairs suggests a generalization of the notion of base pairing stating that under some conditions amino-acids coded by XYZ and UY_cV can behave like base pairs. These amino-acic pairs correspond to pairs of amino-acid residues which are hydrophilic *resp.* hydrophobic and hydrophobic residue do not form hydrogen bonds in general. These flux tubes would thus be more general and in general long. The model for DNA as topological quantum computer requires this kind of flux tubes and they would in general connect atoms or molecules which act as acceptors in hydrogen bonding: O = atom in amino-acid and aromatic ring are basic examples.
3. If one assumes that both $N-H$ and O = associated with the constant part of the amino-acid can act as flux tube terminals and represent Z and Y nucleotides of the codon XYZ coding for the amino-acid, one obtains $Y = Z$ pairing of $O = -O$ = flux tubes are allowed and $Y = Z_c$ pairing if only hydrogen bond like pairings are allowed. Direct check shows that $Y = Z$ pairing is surprisingly successful.

The phase transitions changing Planck constant change the length of flux tube and these phase transitions could be a main tool of bio-catalysis. The contraction of flux tubes connecting bio-molecules brings them near to each other and this explains why they are able to find each other in miraculous manner (see **Fig.** <http://tgdtheory.fi/appfigures/fluxtubedynamics.jpg> or

Fig. ?? in the appendix of this book). Also a detailed understanding about DNA as topological quantum computer emerges [K3]: the acceptors of hydrogen bond (aromatic rings, $O =$ atoms, ...) serve as fundamental plugs at which flux tubes terminate and continue further. Also a direct connection with the basic metabolic process $ATP \rightarrow ADP + P_i$ emerges: this process can be identified as temporary splitting of the flux tube implied by the reconnection process between the flux tube connection the $O =$ atoms of second and third phosphate of ATP and hydrogen bond connecting two water molecule. Flux tube connections would also provide an explanation for the properties of gel phase in cell interior and the phase transitions changing Planck constant would induce the phase transitions of gel phase (say gel-sol transition) [K96] suggested to be a basic mechanism behind various biological functions in molecular and cell scale [I125].

2. Second vision

The mathematical realization for the hierarchy of Planck constants leads to a generalization of the notion of embedding space and this leads to four kinds of phases resulting as combinations of phases with increased or reduced unit of spin and quantum numbers associated with CP_2 degrees of freedom. Each phase corresponds to its own Planck constant and is characterized by a discrete symmetry group.

Especially interesting are phases with a maximal value of Planck constant involving charge fractionization and increase of spin unit. The free electron pairs of aromatic cycle are reasonable candidates for dark electrons of this kind. This means that one can consider variants of hydrogen atom with a fractional electron charge and the obvious idea is that the values of fractional charge would define “names” and their “conjugate names”. Thermal stability poses strong constraints since atomic and molecular energy scales are reduced as Planck constant increases.

The notion of fractional electron inspires the notion of “half” hydrogen bond for which electron has a fractionized fermion number. The full hydrogen bond would be formed in the fusion of half hydrogen bonds and give rise to a structure analogous to a full electron shell expected to be especially stable. Catalyst sites might correspond to half hydrogen bonds and the basic recognition mechanism could be the fusion of half bond and its conjugate to form a full hydrogen bond. One could speak about “molecular sex”. The sequences of half bonds would represent words so that molecules would have names. Also interpretation as quantum computer codes might make sense.

The problem of this vision is the lack of direct contact with experimental facts and for this reason it will not be discussed in the sequel.

8.2.3 Some Mechanisms Liberating Metabolic Energy And Connection With Free Energy Phenomena

In this section possible mechanism liberating metabolic energy are discussed. All these mechanisms can be combined with time mirror mechanism (see **Fig.** <http://tgdtheory.fi/appfigures/timemirror.jpg> or **Fig. ??** in the appendix of this book).

It must be admitted that the recent view about the real purpose of metabolism is as negentropy transfer and it is not clear whether a liberation of energy necessarily accompanies the process. I do not understand well enough the relationship of NMP with second law to be able to answer this question. It seems that when the generation of dark matter is allowed, second law ceases to hold.

Certainly the feed of negentropic entanglement is accompanied by that of dark energy and if this dark energy is transformed by living matter to ordinary energy with standard value of Planck constant, entropy is produced very effectively. The reduction of the length of magnetic flux tube is one of the basic processes taking place at molecular length scales and corresponds to a reduction of \hbar_{eff} being therefore dissipative so that the ordered energy is transformed to non-ordered form. The dissipation would be basically due to the fact that living systems at all levels of the hierarchy do their best to stay at their level of criticality since the phase transition increasing \hbar_{eff} means death of the self.

Some mechanisms liberating metabolic energy

In the earlier approach metabolism as liberation of ordered energy assumed to carry information was in a central role. In the recent view this essentially thermodynamical approach is replaced by

that inspired by NMP: metabolism is seen basically transform of negentropic entanglement (NE). I have already discussed briefly the options for how the nature of transferred NE (either short distance NE or long distance NE).

Several mechanisms liberating metabolic energy are possible and very probably many of them are important.

1. The dropping of ions from space-time sheet to a larger one liberates energy. The liberated energy is essentially the difference of the zero point kinetic energies associated with the space-time sheets. Zero point kinetic energy derives from Uncertainty Principle: the smaller the box where particle is forced to move, the higher the momentum uncertainty and the larger the zero point kinetic energy.

In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant \hbar_{eff} so that cyclotron energy would be liberated. In the following only the “dropping” option is discussed.

2. The ion dropped to a magnetic flux tube can have very high cyclotron energy gradually dissipated as ELF MEs when the ion drops from the cyclotron state with magnetic quantum number $n \simeq f_h/f_{ELF} \gg 1$ by a stepwise process $n \rightarrow n-1 \rightarrow n-2 \dots$ to the ground state. The energy liberated in this process can be utilized by magnetic bodies at various levels of dark matter hierarchy. The mechanism is emission of negative energy dark photons inducing a coherent dropping of ions to lower cyclotron states. Magnetic bodies could share a considerable portion of metabolic energy used in brain.
3. A variant of this mechanism involves dropping of a photon BE condensed at ME parallel to a linear structure and having a frequency which is multiple of f_h to a magnetic flux tube transversal to the linear structure and its absorption by a super-conducting ion. Also this mechanism generates ELF MEs with a fixed f_h/f_{ELF} ratio for a given ion at the super-conducting magnetic flux tube.

Liberation of metabolic energy via the formation of bound states

The formation of bound states liberates also energy. At the level of conscious experience the formation of bound states corresponds to a fusion of mental images to higher level mental images and a loss of consciousness at the level of fusing selves. Sharing of mental images corresponds to fusion of sub-selves of two unentangled selves to single sub-self. The sharing of mental images is allowed only by the TGD based definition of subsystem relying on the notion of length scale resolution. For instance, the fusion of left and right visual fields to single visual field would give rise to stereo vision in this manner.

Binding energy could be liberated as coherent photons at some level of the dark matter hierarchy and utilized for metabolic purposes. The beautiful aspect of this mechanism is that the liberation of metabolic energy is accompanied by the generation of higher level mental images, and the higher the amount of energy liberated, the longer lasting the mental image is. The value of Planck constant is even more important since the de-coherence time is expected to be proportional to \hbar .

1. Gravitational binding energies for blocks of water in the biologically most interesting length scale range $L(151) = 10 \text{ nm} - L(167) = 2.5 \text{ } \mu\text{m}$ correspond to frequencies in ELF range. The immense spin glass degeneracy implied by space-time surfaces differing only by classical gravitational energy encourages to think that the generation of gravitationally bound states generates ELF MEs. The objection is that the energy of one ELF ME is quite too low and that one needs large number of ELF MEs to achieve statistical reliability for the sensory representations.

2. The role of the metabolism in the generation of the bound state entanglement suggests that the natural energy scale is in the range of molecular and atomic binding energies. Bound state energies are typically measured in electron volts from the bond energy of hydrogen bond. At DNA level the generation of hydrogen bonds correlate gives rise to generation of projector MEs. If so, hydrogen bonds connecting blood and cellular liquid to cluster would be responsible for the generation of the hydrogen bonds. This is consistent with the idea that water liquid crystals amplify and represent. There is however no obvious mechanism for the generation of ELF MEs.
3. The formation of water clusters is also a good candidate for the mechanism generating bound states and could play crucial role in the metabolism. The binding energy .485 eV of hydrogen bond which is very near to the energy associated with the p-adic length scale $L(163)$ is expected to define the length of ME generated in this process. This process could be especially important at DNA level.

Liberation of zero point kinetic energy in dropping of ions to larger space-time sheets as a source of metabolic energy

In TGD the simplest manner to liberate usable energy is the dropping of ions from the atomic space-time sheets to super conducting space-time sheets. Since the difference of the zero point kinetic energies is inversely proportional to the mass of the ion, proton is optimal in this respect. The energy liberated when the proton drops from the atomic space-time sheet to much larger space-time sheet is about $3\pi^2/2m_p a^2 \simeq .4932$ eV for $a = L(137) = L(151)/128 = .78$ Angstrom and very near to the metabolic energy liberated when single ATP molecule is utilized. This energy is also amazingly near to the energy $E = 2\pi/L(163) = .4921$ eV defined by the p-adic length scale $L(163)$ defining one of the miracle length scales associated with Gaussian Mersennes. With the scaling $L(151) = 10$ nm $\rightarrow xL(151)$, $x = 1.002$, allowed by experimental uncertainties these energies are identical.

The dropping of the protons from the atomic to the super-conducting space-time sheets explains also the strange findings of Irving Langmuir [D32] and the over unity energy production in water hydrolysis (also involved with the utilization of ATP!). In the generation of single ATP molecule 3 protons are accelerated in the electric field generated by the liberation of the metabolic energy. These observations do not leave much freedom of choice: the flow of protons between super-conducting and atomic space-time sheets is the basic mechanism of the energy economy in the living matter: energy is liberated when the proton drops to the atomic space-time sheet and the charging of the energy batteries means that the protons are kicked back to the atomic space-time sheets.

Fractality suggests that also other ionic flows define similar cycles in smaller energy scales and ATP cycle takes only care of the most roughest energy metabolism. For instance, the dropping of Ca^{++} ion would give rise to energy of in various biologically important ions would liberate energy of about .01 eV if proton liberates energy of .5 eV. The corresponding photon wave length is about 100 microns. The excitation of high n cyclotron states is possible also now and the generation of ELF MEs at multiples of cyclotron frequencies could give rise to sensory representations and contribute to EEG.

Connection with free energy anomalies

1. Anomalies discovered by Langmuir

The first class of anomalies is known more than a century and were discovered by the nobel chemist Irving Langmuir [D32] while developing the first electric lamps based on electrode consisting of tungsten wires. Langmuir made three discoveries which have been forgotten since then, perhaps because they are very difficult to understand in the framework of existing chemistry.

1. The first observation was that the heating of tungsten wire in vacuum to get rid of the gas inside it liberated practically unlimited amount of gas. Langmuir stopped the process when an amount of gas equivalent with 7000 volumes of tungsten wire had been evaporated. The question Langmuir posed himself was "Where this gas comes". I do not know whether

Langmuir found any satisfactory answer but a very attractive possibility is that the heating allows the transfer of gas ions from super-conducting magnetic flux tubes to the atomic space-time sheets. This would indeed imply that the tungsten wire could act as effectively endless source of gas.

2. The second observation of Langmuir was that the energy liberated in the electrolysis of water to hydrogen and oxygen in presence of electric current in electric voltage in Volt range liberated energy which was by a factor of order 10^3 higher than the energy deduced from the binding energy of the hydrogen molecule. This suggests strongly that the electrolysis somehow generated bound states and that binding energy was liberated. The simplest explanation would be the dropping of ions to the magnetic flux tubes by a process in which they emit the difference of zero point kinetic energies for initial space-time sheet and magnetic flux tube as the kinetic energy as a photon emitted in the process. The energy could also be liberated when the magnetic field penetrates to matter, say metal, implying that the hydrogen atoms collide with the atoms of the metal. The basic function of the electric voltage and electron current in this process would be the splitting of the bonds binding hydrogen to the water.

One can consider also the possibility that the binding of the hydrogen atoms to hydrogen molecules did not occur as two-particle process but involved the formation of water clusters and the liberation the binding energy.

Similar process might be involved with the generation of ATP which involves acceleration of hydrogen ions in membrane potential. Therefore the energy liberated in generation of ATP would be many orders of magnitude higher than expected and could give rise to generation of bound states as well as generation of MEs projecting to the sensory magnetic canvas.

3. The third strange observation of Langmuir was that the heat conductivity of the hydrogen gas created in the lamp was anomalously high. This could be understood if the hydrogen atoms or ion propagating along magnetic flux tubes during the conduction of the gas hydrogen ions liberated their energy when the magnetic field penetrated to a target material forcing hydrogen atoms to collide with the atoms of the material.

2. Strange properties of Brown's gas

There is also a connection with the strange properties of the so called Brown's gas discovered by Prof. Yul Brown [J84]. Brown's gas results in the electrolysis of water using electric current running between oppositely charged plates in a voltage which is below 1.7 V. What is believed to occur is the electrolysis of water to oxygen and hydrogen atoms. The flame of hydrogen resulting in the electrolysis appears to have low temperature. When the flame is directed to a metal, it melts and one of the applications is welding of metals. The temperature of the metal remains the melting temperature during the melting. The process involves a liberation of energies which are several times higher than expected on basis of the binding energy of hydrogen atoms to oxygen and the electric power fed to the system.

The TGD based explanation would be that hydrogen atoms and/or ions drop at larger space-time sheets such as magnetic flux tubes of Earth and get additional kinetic energy as the increment of the zero point kinetic energy resulting from the localization inside space-time sheet. The estimates for the molecular weight of Brown's gas are consistent with the molecular weight of H_2O but also with the atomic weight of oxygen in a good approximation. If Earth's magnetic field penetrates to the atomic space-time sheets of the metal, then the hydrogen atoms flowing along magnetic flux tubes enter to the atomic space-time sheet of metal and collisions with the atoms of metal lattice occur and heat it and induce a phase transition leading to the melting of the metal. The liberation of the zero point kinetic energy means effective over-unity energy production in case that the ions at the magnetic flux tubes interact with a matter with the binding energy being liberated. If this interpretation is correct, living matter would construct the sensory representations using the same mechanism that explains the strange properties of Brown's gas.

3. Biefeld-Brown effect

Also Biefeld-Brown effect allows explanation as a recoil effect in many-sheeted space-time. For long time ago T. T. Brown observed [H2, H8, H10] that when capacitor plates are loaded

with opposite charges by coupling the capacitor to a voltage source, it jumps to the direction of the second plate. The magnitude of the effect depends on the voltage and begins to decrease above some critical voltage and eventually changes its sign. What is strange is that neither energy nor momentum conservation do not seem to hold true if one assumes that only electric energy is liberated: momentum and energy simply seem to appear from nowhere.

The explanation is in terms of a recoil effect in many-sheeted space-time. When the voltage is coupled on, the ions with opposite charges rush to the capacitor plates. By their inertia some of them leak to larger space-time sheets (the mechanism of auroras and breakdown of superconductivity is essentially the same [K24]). The difference of the binding energies is liberated as additional kinetic energy and momentum of the dropped ion and the recoil momentum is obtained from the elementary text book formulas $E_f = E_i + \Delta E$, $E = p^2/2m$ as

$$\Delta p = -p_i \left(\sqrt{1 + \frac{\Delta E}{E_i}} - 1 \right) ,$$

where ΔE denotes the difference in zero point kinetic energies for a charged particle of mass m and subscripts i and f refer to initial and final states of the charged particle. These recoil momenta are absorbed by the entire system and give rise to a recoil effect if the recoil momenta from the plates do not exactly compensate each other. This is not expected to happen since the positive and negative charge carriers have widely different momenta due to the widely different masses and different velocities.

For definiteness assume that there are only electrons and ions of single type; that they drop to single space-time sheet only; and that capacitor plates have opposite charges during loading so that ionic and electronic currents are of opposite sign at the capacitor plates during loading. Under these assumptions the ratio of the momenta is

$$\frac{p_i(e)}{p_i(I)} = \frac{m_e n_I}{m_I n_e} ,$$

where $n(e)$ ($n(I)$) refers to the density of the electrons (ions). Combining this with the previous equation, one has

$$\frac{\Delta p(e)}{\Delta p(I)} = -\frac{m_e n_I}{m_I n_e} \frac{\left(\sqrt{1 + \frac{\Delta E(e)}{E_i(e)}} - 1 \right)}{\left(\sqrt{1 + \frac{\Delta E(I)}{E_i(I)}} - 1 \right)} .$$

When several ions are present, one must construct a more elaborate model. Also an effect tending to change the mutual distance of the plates is predicted.

The effect is proportional to the charge of the capacitor plate and thus to the voltage but depends on voltage in nonlinear manner. since the recoil momenta due to electrons and ions depend on non-linear manner on voltage. The change of the sign of the effect when voltage increases should be due to the fact that the velocities gained by ions and electrons depend on the voltage in different ways. The electronic band structure of the conductor could play an important role in the effect.

This mechanism is obviously ideal mechanism of locomotion in living matter and it would be surprising if bio-systems would not have invented it.

8.2.4 The Challenges Posed By The New Ideas

After writing the first draft of this chapter for more than decade ago several new insights and ideas have emerged. Therefore I decided to try to fuse these new ideas with the older vision. This required re-organization of the entire chapter and I was also forced to split it into two parts separating the stuff strictly related to metabolism. As usual there was also some obsolete stuff related to assumptions which in hindsight look ad hoc. Few years after writing this section I realized that many fresh ideas have emerged and it seems that also this section needs updating.

Unification of different views about how living matter is macroscopic quantum system

The identification of dark matter realized a hierarchy of phases labeled by the value of Planck constant [K47], the idea that negentropic entanglement possible for algebraic entanglement probabilities characterizes living matter [K73], and living matter as super-conductor [K23] are three separate ideas of TGD inspired theory of quantum biology and it now seems possible to unify these ideas.

1. The view about hierarchy of Planck constants has simplified considerably. One can speak about effective value of Planck constant and identify the integer characterizing the number of sheets of the local covering of embedding space allowing a convenient description for the fact that the correspondence between canonical momentum densities and generalized velocities defined as time derivatives of the embedding space coordinates is one-to-many.

In fact, it seems that the time derivatives in the interiors can have this kind of multi-valued relationship to canonical momentum densities. The space-time surfaces would be multi-branched and could be seen as surfaces in the covering space of the embedding space. The space-like 3-surfaces at the ends of space-time sheets at light-like boundaries of CD and the light-like 3-surfaces at which the signature of the induced metric changes would be analogous to the points at which a cut of analytic function begins: origin for \sqrt{z} is the simplest example about this. The branching of the space-time surfaces would take place at these 3-surfaces. The branching would be n_1 -fold at space-like 3-surfaces for each branch emerging in n_2 -fold branching at light-like 3-surfaces. At partonic 2-surfaces $n = n_1 n_2$ branches of the space-time sheet would degenerate to single one. That the branchings occur at two kinds of 3-surfaces corresponds to the effective 2-dimensionality forced by strong form of holography in turn forced by the strong form of general coordinate invariance.

This brings strongly in mind stacks of branes and one can expect similar mathematical structures such as appearance of dynamical gauge group $U(n)$ having interpretation in terms of finite measurement resolution and characterizing inclusion of hyper-finite factors of type II_1 with included factor defining analogs of local gauge transformations generating states equivalent within measurement resolution.

2. The idea about living matter as something residing in the intersection of real and p-adic worlds - intersection of matter and cognition- is very powerful [K80, K73]. One implication is the notion of negentropic entanglement (see **Fig.** <http://tgdtheory.fi/appfigures/cat.jpg> or **Fig. ??** in the appendix of this book) possible for rational or quantum rational [K84] entanglement probabilities (and also entanglement coefficients but in larger algebraic extension). Negentropic entanglement is not generic but is favored and stabilized by NMP. The natural idea is that negentropic entanglement at molecular level distinguishes between living and inanimate matter.

Also bound state entanglement is stable under NMP but in general entropic. Negentropic entanglement can be however stable even when binding energy is formally negative. The natural crazy idea is that so called high energy phosphate bond formally corresponds to negative binding energy and carries entanglement negentropy. This leads to the idea that energy metabolism is basically about transfer of conscious information or quantum communication meaning re-arrangement of the magnetic flux tubes connecting distance molecules serving as a correlate and a pre-requisite for negentropic entanglement.

What could be the carriers of the negentropic entanglement in living matter?

1. The first guess is that they are electrons of electron pair with a vanishing spin. The geometric size of an electron pair assignable to a valence bond cannot however scale like \hbar . One can however assign the large value of \hbar to the magnetic body of the electron pair. The larger the value of \hbar , the larger the magnetic body. Support for the fundamental role of electrons in biology comes from the observation that the time scale associated with electron's CD is 1.1 second and corresponds to the fundamental biorhythm [K44].
2. Another key hypothesis is that electronic super-conductivity [K23] is a key aspect of living matter and this suggests that the electron pairs associated with covalent bonds and having

large \hbar are responsible for this super-conductivity and that negentropic entanglement characterizes large \hbar phase. This suggests a connection between several ideas: dark matter hierarchy as hierarchy of Planck constants, bio-systems as super-conductors, negentropic entanglement characterizer of living matter, and metabolism as transfer of negentropic entanglement in some sense.

This looks nice but one encounters a difficulty. For ordinary atoms the spin of electron pair in the valence bond however vanishes so that also the dipole contribution to the magnetic field of the pair vanishes. This does not favor the idea about electrons pairs forming a Bose-Einstein condensate connected by flux tubes to a larger structure.

1. Could one assume that dark valence electrons pair to form $S = 1$ states in living matter so that the resulting magnetic field would be dipole field in the lowest order and the flux tubes would naturally connect electron pairs in the direction of the flux tubes to larger quantum coherent structures and one would obtain super-conductor? This idea is not so unrealistic as it looks first since spin 1 states are indeed assumed in the model of high T_c super-conductivity. These states couple to orbital angular momentum $L = 1$ to form $J=2$ Cooper pairs [K23].

Electronic Cooper pairs at valence bonds could generate the magnetic body. The flux tubes of the magnetic body would in turn bind the proteins to quantum coherent larger scale structures. By their small mass as measured in the protein mass scale electron pairs would obey a very swift dynamics whereas the much slower dynamics of proteins would be determined by the electromagnetic forces due to them. Electronic super-conducting phases could control the protein dynamics in the sense that quantum jumps for the macroscopic quantum state of super-conducting electrons would induce large scale conformational changes.

2. The second guess is based on the idea that the electron pairs form a super-conductor like macroscopic quantum phase made possible by the overlap of the wave functions for large values of \hbar . Negentropic entanglement could be between the members of electron pairs and between the pairs themselves. The latter option make possible quantum communications involving entanglement between distance biomolecules at the ends of the magnetic flux tubes connecting them. This clearly favors bio-molecules possessing maximal number of electron pairs since the density of electron pairs is maximized in this manner.
3. Especially important transformations would be the phase transitions reducing or increasing \hbar . They would induce the scaling of flux tube lengths and compression or extension of the protein system such as cytosol [K13].
4. Suppose that electrons with dark magnetic flux tubes with size scale of Compton length proportional to \hbar and having negentropic entanglement characterize bio-molecules but not the molecules of inanimate matter for which electron pairs at valence bonds have vanishing spin. In this framework metabolic energy could help to generate negentropic entanglement or make possible the re-organization of the negentropic entanglement using $ADP + P_i \rightarrow ATP$ process as a way to reconnect the magnetic flux tubes serving as correlates for this entanglement. The latter option looks more plausible. The ageing of the organism could basically mean a loss of negentropic entanglement implied by the loss of spin 1 electron pairs associated with the valence bonds.
5. The photons of sun-light should arrive along magnetic flux tubes with large value of Planck constant. They could leave Sun as large \hbar photons or transform to such in Earth's magnetosphere. The latter option is more plausible. The simplest option is that they provide the dark metabolic energy needed to manipulate the negentropic entanglement between bio-molecules.

If this view is on the correct track, biological evolution would tend to maximize the number of negentropic covalent electron pairs and simple checks show that basic biomolecules indeed tend to maximize this number and phosphates crucial for metabolism are especially negentropic. Also the idea about peptides as information molecules conforms with the idea about electron pairs as carriers of negentropic entanglement. Peptides are also molecules of emotion and this suggests that the large \hbar negentropic entanglement is crucial for understanding emotions. One can naturally assign positive emotions to the generation of negentropic entanglement and negative emotions to its loss.

Generalization of second law and living systems

In TGD Universe the generalization of negentropic entanglement is possible and forced by NMP [K73]. Does this mean that second law is lost? One can argue that this is not the case and experimental evidence supports this view. For a given CD the entanglement can be negentropic below the time scale characterizing it. Above this time scale ensemble description is necessary and second law holds true and is basically due to the non-determinism of quantum jump just as it is for the ordinary entanglement. Years after writing the above lines I must add an important restriction: second law holds if matter is not transformed to dark matter permanently during process considered.

Perhaps it was conformism which led to a proposal what I called pessimistic view. A more pessimistic view is that the generation of negentropic entanglement is accompanied by generation of a compensating entropic entanglement somewhere else. Few years later this idea looks ad hoc.

One could say that living matter would differ from inanimate matter in that it has discovered dump pit. One can try to formulate this conjecture more precisely and try to identify the mechanism generating the entropic entanglement.

1. If the end products of biological processing are molecules characterized by the ordinary value of Planck constant, the entanglement assignable with them - in particular covalent electron pairs - is entropic. One could interpret the transformation of negentropic electronic entanglement to entropic one as a realization of the strong form of Second Law. In photosynthesis involving photons from Sun would induce a phase transition increasing the Planck constant for the pairs and making them negentropic again. Biological death would mean the transformation of spin 1 negentropic electron pairs to ordinary spin 0 entropic electron pairs. The basic difference between bio-chemistry and ordinary one would be the presence of these spin 1 pairs of electrons.
2. One can also consider the possibility that also the end products of metabolism have non-standard value of Planck constant and that only the bio-molecules containing un-paired electrons-that is free radicals (see <http://tinyurl.com/5p5jan>) [I20] such as O_2 are entropic. Free radicals are known to cause damage to DNA and believe to be responsible for degenerative diseases, cancer, and senescence. The reason is that they are very reactive and reaction induce formation of electron pairs. This would induce transformation of large \hbar electron pairs in living matter to ordinary electrons pairs with the unpaired electrons of free radical and would tend to reduce the negentropy. This might happen in cell respiration believed to produce CO_2 and H_2O as "wastes". The attribute "waste" would apply naturally if the valence electron pairs are ordinary ones for CO_2 and H_2O . One can however imagine also the transformation of these electrons to electron pairs with large \hbar in chemical reactions so that the situation remains unclear.
3. One can also wonder what is the Planck constant the valence electron pairs of the ordinary water. Could it be large and could the water resulting as the end product of metabolism have ordinary value of Planck constant?

Realizations of the genetic code

TGD suggests several realizations of the genetic code [K58, K132, K1, K149]. This would conform with what we know about information society in which there is a proliferation of codes basically due to the fact that the basic feature of computers is that they are able to emulate each other and with the fact that living matter is basically information processor.

1. I discovered one new realization of the genetic code by accident as I constructed a model for dark proton and observed that the states of dark proton are in one-one correspondence with the DNA, RNA, tRNA, and amino-acids [K58, L3]. DNA sequences would correspond to dark nuclei realizes as strings formed from dark proton sequences. They would be accompanied by magnetic flux tubes generated the magnetic fields of dark protons if their spins are along the flux tube direction. The observation that water obeys the effective chemical formula $H_{1.5}$ in atto-second time scale suggests that 1/4 of protons of water are dark [K43].

2. The vision about DNA as topological quantum computer is very general [K3]. The essential element is the coding of DNA nucleotides and one can imagine several options. One realization is based on the representation of DNA nucleotides A, T, C, G as quarks u, d and their antiquarks and requires scaled up version of QCD. If quark pairs are unavoidable, one must understand how the correspondence of A, T, C, G with quarks and antiquarks emerges.

Second option would be use spin 1 triplet and spin 0 singlet formed from two dark electron pairs with mixing of singlet and $S_z = 0$ state of triplet. The pair of electron pairs would be assigned to a pair of magnetic flux tubes emanating from $O =$. This option would allow unification of DNA as topological quantum computer conjecture with the conjectures about dark high T_c super-conductivity and negentropic entanglement. Now one should understand the coding of A, T, C, G by the pairs of electron pairs. Basically one should understand two correspondences: the correspondence of dark protons with DNA, RNA, tRNA, and amino-acids inducing genetic code and the correspondence of pairs of electron pairs with these.

3. One can also imagine codes based on field patterns and dynamical realizations of the genetic codes [K58, K132, K1, K149].
4. During 2014 I developed a model of music harmony and genetic code [K95] predicting a realization of genetic codes using 3-chords which can be assigned with the 20 triangles at the surface of icosahedron and 4 triangles at the surface of tetrahedron. The harmony is characterized by a Hamiltonian cycle at icosahedron representing 12 notes of the 12-note scale. The model predicts standard genetic code and its modification corresponding to icosahedron and tetrahedron, which are either disjoint or glued together along a common triable. In the new code 2 additional amino-acids appear. It is known that standard code is not quite unique (wobble phenomenon), and the predicted two codes might be assigned to the two strands of DNA: maybe they could be seen as different dialects of language.

At the level of magnetic body there would be 256 different bio-harmonies, whose interpretation as molecular moods might make sense. The realization of the bioharmony could be in terms of 3-chord sequences represented as sound or dark photons. The natural definition of harmony could be as a condition that the subsequent DNAs/amino-acids correspond to chords which are nearest neighbors as triangles at the surface of icosahedron. It is relatively easy to code random chord sequences using MIDI language and they sound rather harmonious.

Flux tubes and DNA

The model of DNA as topological quantum computer gives useful guide lines in the attempt to form a vision about flux tubes. It was assumed that braid strands defined by “wormhole magnetic” flux tubes join nucleotides to lipids and can continue through the nuclear or cell membrane but are split during TQC. The hydrophilic ends of lipids attach to water molecules and self-organization patterns for the water flow in gel phase induce a 2-D flow in the lipid layer which is liquid crystal defining TQC programs at the classical level as braidings. The flow indeed induces braiding if one assumes that during topological computation the connection through the cell membrane is split and reconnected after the halting of TQC.

The challenge is to understand microscopically how the flux tube joins DNA nucleotide to the phospholipid [I36]. Certainly the points at which the flux tubes attach should be completely standard plugs and the formation of polypeptide bonds is an excellent guide line here. Recall that phospholipid, the TQC dancer, has two hydrophobic legs and head. Each leg has at the hydrophilic end $O=C-O-C$ part joining it to glyceride connected to monophosphate group in turn connected to a hydrophilic residue R . The most often appearing residues are serine, inositol, ethanolamine, and choline. Only three of these appear in large quantities and there is asymmetry between cell exterior and interior.

1. *Are the flux tubes beginning from $O =$: special?*

Let us denote by O_1 and O_2 the two oxygens (maybe analogs of right and left hemispheres!) in question.

1. The proposal is that DNA nucleotide and $= O_1$ are connected by a flux tube: the asymmetry between right and left lipid legs should determine which of the legs is “left leg” and which $O =$ is the “left brain hemisphere”. $= O_2$, the “holistic right brain hemisphere”, connects in turn to the flux tube coming from the other symmetrically situated $= O_2$ at the outer surface of the second lipid layer. Besides this $= O_1$ and $= O_2$ are connected by a flux tube serving as switch on both sides of the membrane.
2. During TQC the short $O = -O =$ flux tube would experience reconnection with a flux tube acting as hydrogen bond between water molecules so that the connection is split and $O =$ forms hydrogen bonds. The reversal of this reconnection creates the connection again and halts the computation. The lipid residue R couples with the flow of the liquid in gel phase. Since $= O$ is in question the quark or antiquark or a pair of electron pairs at the end can correspond to the DNA nucleotide in question. The necessary complete correlation between quark and antiquark charges at the ends of flux tubes associated with $= O_1$ and $= O_2$ might be understood as being due to the minimization of Coulomb interaction energy. In the case of pair of electron pairs the correlation could come from the minimization of the magnetic energy.
3. If one is ready to accept magnetic flux tubes between all acceptors then the aromatic rings of nucleotides known to be acceptors could be connected by a flux tube to the $O =$ atom of the lipid or to some intermediate $O =$ atom. The phosphate groups associated with nucleotides of DNA strand contain also $= O$, which could act as a plug to which the flux tube from the nucleotide is attached. The detailed charge structure of the aromatic ring(s) should determine the quark-nucleotide correspondence. The connection line to the lipid could involve several intermediate $O =$ plugs and the first plug in the series would be the $O =$ atom of the monophosphate of the nucleotide.

There is a strong temptation to assume that subset of XYP molecules, $X = A, G, T, C$, $Y = M, D, T$ act as standard plugs with X and phosphates connected by flux tubes to a string. This would make it possible to engineer braid strands from standard pieces connected by standard plugs. DNA nucleotide XMP would have flux tube connection to the aromatic ring of X and the $O =$ of last P would be connected to next plug of the communication line. If so, a close connection with metabolism and topological quantum computation would emerge.

1. Phosphorylation [I37] would be an absolutely essential for both metabolism and buildup of connection lines acting as braid strands. Phosphorylation is indeed known to be the basic step activating enzymes. In eukaryotes the phosphorylation takes place amino-acids most often for ser but also thr, and trp with aromatic rings are phosphorylated. Mitochondrions have specialized to produce ATP in oxidative phosphorylation from ADP and photosynthesis produces ATP. All these activities could be seen as a production of standard plugs for braid strands making possible directed attention and quantum information processing at molecular level.
2. As already noticed, $O = -O =$ flux tubes could also act as switches inducing a shortcut of the flux tube connection by reconnecting with a hydrogen bond connecting two water molecules. This is an essential step in the model for how DNA acts as topological quantum computer. De-phosphorylation might be standard manner to realize this process.
3. This picture would fit with the fact that XYP molecules, in particular AMP, ADP, and ATP, appear in bio-molecules involved with varying functions such as signalling, control, and metabolism. $= O$ might act as a universal plug to which flux tubes from electronegative atoms of information molecules can attach their flux tubes. This would also provide a concrete realization of the idea that information molecules (neurotransmitters, hormones) are analogous to links in Internet [K96]: they would not represent the information but establish a communication channel. The magnetic flux tube associated with the information molecule would connect it to another cell and by the join to $= O$ plug having flux tube to another cell, say to its nucleus, would create a communication or control channel.

2. DNA as topological quantum computer hypothesis and electronic super-conductivity

The vision about DNA as topological quantum computer is very general. The essential element is the coding of DNA nucleotides and one can imagine several options.

1. One realization is based on the representation of DNA nucleotides A, T, C, G as quarks u, d and their antiquarks and requires scaled up version of QCD. The motivation for this realization came from the observation of Barbara Shipman that the mathematical description of honeybee dance suggests that quarks play a role in living matter [A6].
2. Second option that one can imagine would use spin 1 triplet and spin 0 singlet of dark electron pair. Spin 0 state for electron pair however gives rise to vanishing dipole field so that flux tube structure would not be possible. Can one circumvent this option or are quark pairs unavoidable?
3. DNA as TQC lead to the hypothesis that it is $O=$ to which one must assign the flux tube pair responsible for the representation of the genetic code. Why $O=$ would be in special role?

- (a) If there are two parallel flux tubes, one obtains tensor product $3 \times 3 = 5 + 3 + 1$ of electron triplets at the ends of the flux tubes. Could it be that A, T, C, and G are represented in terms of 3 and 1 and the breaking of rotational invariance implies a mixing of singlet and spin 0 state of triplet so that nucleotides and their conjugates could correspond to the resulting two pairs related by reflection?

One can however argue that for $S_z = 0$ states the direction of the magnetic flux tubes is orthogonal to that in other cases. An alternative possibility is that one uses only the four $S_z \neq 0$ states of spin 2 5-multiplet obtained in the tensor product. The breaking of the full rotational symmetry down to $SO(2)$ symmetry around flux tube direction could be used to justify this option.

- (b) The coding would be also consistent with quantum classical correspondence since it would reduce at classical level to a coding in terms of directions of magnetic fields in the two flux tubes: the directions could be parallel and in two directions or antiparallel giving also two options: four altogether. Notice however that one must be able to distinguish between two different configurations in which the directions of magnetic flux are opposite for the flux tubes of the pair. Classically this is achieved if the flux tubes form either a right-handed or left-handed double helix. Double helix could also resolve the problem posed by the fact that in $S_z = 0$ case the flux tubes cannot be parallel to their common axis at the flux tube end.
- (c) This option would allow a unification of DNA as topological quantum computer conjecture with the conjectures about dark high T_c super-conductivity and negentropic entanglement.

$ATP \rightarrow ADP + P_i$ would correspond to the fusion of flux tube pair with two hydrogen bonds associated with water molecules so what they could become short-circuited with water molecules. The reverse process would create flux tube connection labelled by the spin state equivalent of A, T, C, or G. The possibility of 5-plet allows also to consider the possibility of five codons instead of four.

Whatever the correct option is it must explain how the correspondence between A, T, C, G and secondary codons emerges.

1. If the pairs of spin triplet electron pairs appear in the correspondence, one must understand why the spin state of the pair of electron pairs at the $O=$ of the phosphate attached with the DNA nucleotide correlates with the character of the nucleotide. Phosphate has also two O^- : s containing two electron pairs. Minimization of the magnetic energy is the explanation which is easiest to imagine. Maybe the total magnetic energy of the pair in the magnetic field of the flux tube structure assignable to the nucleotide plus the de-oxynribose preceding it. T and C contain also $O=$ but not A and G. and A and T and C and G are conjugates.

By studying the chemical structure of DNA (see <http://tinyurl.com/yd7b7w98>) [I86] one finds that the pairs AT and CG contain two $O=$: s which belong either to same nucleotide

(to T in A-T) or to different nucleotides (C-G). This suggests the coding in which there are flux tube pairs connecting the two phosphate O=s at the two sides of the double strand and going through the two intermediation O=s. The rule would be that the spin states are conjugates at the ends of the flux tubes. A-T and T-A pairs could correspond to parallel flux tubes with same direction of the flux and G-C and C-G to parallel flux tubes with opposite directions of the magnetic fluxes.

2. If quark pairs are unavoidable, the correspondence of A, T, C, G with quarks and antiquark must relate to quark charges coming as $\pm 2/3$, $\pm 1/3$. Also in this case the coding mechanism based on the flux tubes connecting O=: s is natural.

The conclusion would be that the original view about secondary realization of genetic code can be replaced with the realization based on spin 1 dark Cooper pairs of electrons between which the entanglement is negentropic. Quark color plays no special role in the model of DNA as topological quantum computer [K3] so that the model remains as such. One implication would be however that the magnetic flux tubes carrying dark electron pairs at their ends could be of astrophysical size.

Challenges

This picture raises challenges. For instance, one should be able to answer the following questions.

1. The basic idea is that the differences of vacuum energies for electrons and protons or their Cooper pairs define fundamental metabolic currencies quantized by p-adic length scale hypothesis. The $ADP \rightarrow ATP$ should thus involve kicking of an electron or proton pair of both to a smaller space-time sheet and its reverse its dropping so that metabolic energy is liberated.

In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant \hbar_{eff} so that cyclotron energy would be liberated. In the following only the “dropping” option is discussed.

The challenge is to relate the proposed transfer of electrons and protons between space-time sheets with different p-adic length scale to the proposed general vision. How the short-cut of the flux tube pair gives to two hydrogen bonds in $ATP \rightarrow ADP + P_i$ gives rise to a dropping of electron pair to a larger space-time sheet. At which end this dropping takes place? At the valence bond of water molecule? Could also proton drop? One can say that the electron pair binds ADP and P_i together. Could the dropping cause the splitting of the valence bond?

One could consider instead of dropping a process in which the bond length and thickness is scaled up by a power of two so that zero point kinetic energy is scaled down. This kind of scaling would occur in a process scaling \hbar for flux tubes but this process would not change the energy. If the length of bond is scaled up this process magnetic energy is not affect but cyclotron energy is scaled down since B would scale like $1/\hbar^2$ and cyclotron energy $\hbar B/m$ like $1/\hbar$. The increase of \hbar would liberate cyclotron energy as photons.

2. The sending of negative energy dark photon (phase conjugate photon) to the geometric past as a basic aspect of metabolism should be also understood in detail. How the absorption of the negative energy photon induces the dropping of the electron pair to a larger space-time sheet? How this dropping appears in $ATP \rightarrow ADP + P_i$. Does it destroy the high energy phosphate bond between P_i and ADP. Is it possible to get energy without the mediation of ATP just by sending negative energy photons?
3. One should understand metabolism in terms of dark nucleons and dark electron pairs. 4 protons and 4 electrons involved with the basic step. At the other side of the mitochondrial membrane protons are fused with oxygen to form water molecules and this induces a transfer

of protons through the membrane from the other side liberating chemical energy making possible $ADP + P_i \rightarrow ATP$. Again one can make questions.

Could the four protons be dark? Could they form two Cooper pairs or a dark nucleus consisting of four protons? Could also proton Cooper pairs with spin 1 give rise to magnetic flux tubes and protonic super-conductivity or super-fluidity? Are proton spins parallel and along a flux tube associated with dark nucleus? Could also DNA and proteins as polymers involve magnetic flux tubes formed by a sequence of charged particles with spins parallel to the flux tube generating the magnetic field giving rise to the flux tube. This would give a net angular momentum to the flux tube. Could it be that this angular momentum is compensated by a rotational motion and generation of flux tubes generates rotational motion by angular momentum conservation?

8.3 General Vision About Metabolism

8.3.1 About Metabolism In General

I summarize the basic facts about blood circulation and red blood cells in the hope of helping the non-biologist reader to get overall view. I hope that the non-professional style of the representation and the unavoidable in-accuracies do not irritate biologists. I introduce also some strange findings and propose how quantum view could allow to understand them.

Cellular respiration

Mitochondria act as power plants of the animal cell. Mitochondria are coded by their own DNA and the DNA is inherited from mother and thus not copied in cloning. If mitochondria contribute to consciousness, as one might suspect, then clones do not experience the world in a similar manner.

ATP is the universal energy currency and TGD based model for ATP generation will be discussed later. Suffice it to say that the energy is transferred to ADP by phosphorylating it in the presence of a suitable ATPase enzyme which usually also catalyzes the transfer of the phosphate molecule from ATP to the client molecule.

Cellular respiration is the basic metabolic process in animals whereas in plants photosynthesis replaces cellular respiration and allows plants to produce glucose used by animals for their metabolism. The basic formula for the respiration is familiar from school days: $C_6H_{12}O_6 \rightarrow 6CO_2 + 6H_2O$ and tells that one glucose molecule is transformed into carbon-dioxide and water and gives in this process the energy stored in it in the photosynthesis. The actual process is however considerably more complex than this oversimplified representation suggests. There are several forms of cellular respiration. Glycolysis is anaerobic respiration mechanism and converts glucose to pyruvate (in particular in neurons and glia). 2 ATP molecules per one glucose molecule are produced and this is enough for the continuation of the glycolysis which itself requires some energy.

Aerobic respiration involves a further processing of pyruvate which is transported to the mitochondria where it is used in Krebs cycle for synthesizing the high energy compounds whose oxidation leads to the generation of ATP. This process is possible only if cell receives oxygen from blood flow. 30-35 ATP molecules per one glucose molecule are produced in this process [J110]. Also fats function as energy reserves: when oxidized they produce 9 times higher energy yield than pyruvate molecules but the rate of the process is slower by a factor of 1/8. Brain does not utilize fat as an energy reserve: rather, astrocytes store the energy reserves of glucose to glycogen which they both synthesize, store, and catabolize.

Lactase and alcohol fermentation represent further an aerobic respiration mechanisms. Lactase fermentation is utilized by muscle cells and after maximal exercise the overproduction of the lactate acid is responsible for the characteristic muscle pain. Some plants utilize alcohol fermentation.

Blood circulation

Blood circulation could be regarded as a logistics of the living system. Logistics involve the delivery of both energetic and structural components such as glucose molecules, oxygen, and proteins.

Blood circulation supports a chemical signalling system based on hormones. Blood acts as a buffering system based on phosphates and proteins and has defensive functions similar to those of immune system. Blood serves also as a reservoir of body heat and blood flow can control the body temperature by convection and conduction mechanisms.

There is a strict separation of the oxygenated and de-oxygenated blood corresponding to pulmonary and systemic flows. The first type of blood vessels are arteries which have walls consisting of smooth muscles which can constrict and dilate and in this manner control the rate of the blood flow. The rate of blood flow depends also on its velocity controllable by the rate of the heart beat. Blood flow is known to be controlled both by hormonal and neural control mechanisms.

Besides arteries there are capillaries which have walls consisting of single layer of cells, endothelium. Capillaries lack the smooth muscle so that the flow to the capillaries must be regulated by precapillary spincters containing smooth muscle and joining arteries to capillaries: their dilation or constriction controls the flow into the capillary. The basic mechanism for transferring molecules from capillaries to cells is diffusion. Lipid soluble molecules like oxygen and carbon monoxide diffuse through cell membranes automatically whereas water soluble molecules can diffuse only through pores. The size of the pores varies and in brain the pores are very small so that blood brain barrier results.

Oxygen is bound to hemoglobin which is a tetramer of four identical myoglobin proteins. Red blood cells transfer the hemoglobin near cell and oxygen diffuses through the wall of the capillary and through the cell membrane to neuron and eventually reaches the mitochondria. Glucose is the energy carrier molecule transferred by blood and glycolysis and aerobic cellular respiration transform the energy stored in the glucose to ATP.

Red blood cells

Red blood cells, being carriers of oxygen, are expected to be especially important for consciousness. Being not a professional biologist I freely use the popular article [I47] in which besides standard facts also the importance of red blood cells and astrocytes for consciousness is also advocated.

Some poorly understood aspects of the blood flow support the idea that blood behaves like a coherent conscious unit under some conditions.

1. The first, already mentioned, mystery is that a heightened neuronal activity induces a rush of blood cells to the neurally active regions but is accompanied by a very low oxidative metabolism.
2. Second mystery is how the signal about the need for the increased blood flow is mediated to the pre-capillaries to relax smooth muscle when blood is needed. Signalling is up-stream and signalling mechanisms based on the diffusion of chemicals like NO, CO_2 and protons, extracellular K^+ and purines have been proposed but no consensus about the mechanism has been reached. An alternative mechanism is based on direct communication to an appropriate magnetic body which in turn would perform the needed motor action.
3. A further mystery is that red blood cells exhibit a coordinated group response to threats [I113]. In light of this the observation that sea stars have a hemal system with no obvious function and, although possessing no brain, are capable of displaying rather refined intelligent behavior [I47], is rather suggestive.

With these observations as a context, it is interesting to try to interpret basic facts about blood flow.

1. Red blood cells are distinguished by their unique role in the oxygen transport and by their anaerobic metabolism (it would not make sense for red blood cells to consume oxygen molecules!). Red blood cells exhibit many characteristics of prokaryotes and might be called metakaryotes: indeed, at some stage of development mammalian red blood cells eject their nucleus and organelles. It has been found that neural cells can be trained to become red blood cells, which supports the view that the role of blood flow is more than mere logistics. Red blood cells are the only cells which are unable to divide and become cancerous.

If one takes seriously the proposal that magnetic bodies perform quantum control through magnetic flux sheets traversing genomes and receive sensory input via flux quanta associated

with proteins traversing cell membranes, this means that red blood cells would communicate only somatosensory input to the respective magnetic body and magnetic and motor control performed through them would be very primitive: perhaps control of motion of blood cell.

Blood cells would correspond to $k_{em} = 1$ level of dark matter hierarchy assigned to prokaryotes. $k_{em} = 1$ and flux quantization for planar flux sheets of thickness $L(169) = 5 \mu\text{m}$, lower bound for the size of cell nucleus, would give length of $\lambda L(169) = 5 \text{ cm}$ for $\lambda \simeq 2000$. Blood cells could perhaps organize to thread like structures parallel to the blood veins.

2. Red blood cells and their hemolymphatic counterparts contain iron and are good candidates for magneto-receptors [J62, J124]. The orientation of the magnetic structures with Earth's magnetic field and the fact that liquid codes the direction of the gravitational field to pressure gradient define a good candidate for a preferred coordinate system used already by honeybees containing magnetite and ferritin in their abdomens [I49]. Red blood cells could serve as compasses and code for the orientation of the body with respect to the magnetic field and gravitational fields and a grid of blood cells could code for the local variations of the magnetic field making possible navigation using magnetic field. This information could be represented at the $k_{em} = 1$ somatosensory magnetic body assignable to the blood flow.
3. The velocity of the blood flow in capillaries is about mm/s so that scaling law gives $f = v/L = 1 \text{ kHz}$, which happens to be the kHz frequency of neural synchrony.
4. Red blood cells exhibit a high capacity for chemiluminescence and it is possible to make red blood cells bioluminescent by genetic engineering. Red blood cells are known to absorb light through the skin and thus might serve as photo-receptors in dermal optics [J125]. In [I47] it is proposed that red blood cells give rise to primitive vision and be responsible for blind sight. Ocular blood vessels are indeed very near to the surface. DNA is believed to generate bio-photons whereas mammalian red blood cells which have no DNA are indeed known to not emit bio-photons [J49]. Perhaps red blood cells "see" the bio-photons generated by DNA: this would conform with the general idea that DNA generates 4-D templates consisting of coherent photons and guiding the biological self-organization.

The large number of mitochondria in the heart muscle, liver and red muscle cell give them their red color. Whether this color is always related to the color of haemoglobin is not clear to me. At least, the idea about a communication system between red blood cells and mitochondria based on red light is worth of demonstrating to be wrong. Unfortunately, I do not know how near the average wave length associated with this red color is to the "miracle wave length" of 640 nm associated with the photons of photosynthesis.

8.3.2 Cellular Respiration And Photosynthesis

Photosynthesis [I38] in which photon energy is chemically stored and cellular respiration in which it is liberated are the fundamental processes of energy metabolism and in some sense duals of each other.

1. Photosynthesis produces from CO_2 and water in presence of sunlight carbohydrates carrying the metabolic energy and serving also as building bricks of more complex bio-molecules. The photon-dependent part of the process extracts the energy of photons and stores it temporarily to ATP and ADPH. This temporarily stored energy drives both the light-dependent and -independent parts of the process and the surplus energy of ATP and ADPH is stored as a chemical energy of carbohydrates (sugars) produced in the process.
2. In cellular respiration the carbo-hydrates are transformed to carbon monoxide and water and metabolic energy is extracted as the energy of ATP molecules serving as a universal metabolic currency to be used for varying purposes.

Both processes are far from being completely understood and the extreme energy efficiency of these processes leaves room for a macroscopic quantum coherence. TGD proposal is that at the deeper level these processes allow interpretation as a transfer or redistribution of negentropic entanglement. The great challenge would be the interpretation of photosynthesis from this point of view.

Cellular respiration

Cellular respiration (see <http://tinyurl.com/yyvrpb>) [I8] a process which converts the chemical energy of nutrients - typically bio-molecules (hydrogen sulfide is however an exception) - to metabolic energy carried by ATP molecule (see <http://tinyurl.com/clnu4>) [I3]. Besides this also waste products are generated.

Oxidation and redox reaction (see <http://tinyurl.com/ycyetr>) [I32] are the key concepts needed in the description of this process.

1. Oxidation means donation of valence electron so that the oxidation state (see <http://tinyurl.com/ya3yj84a>) [I33] of the atom is changed. Typically the electron is paired with an electron of the receiving atom so that an electron pair assignable with a valence bond is formed: the oxidation state of the atom increases by one unit. Typically oxygen receives the electron and this has given the name for the process. Reduction is the reverse of this process: atom or molecules donates an electron to the acceptor.
2. A simple example is H_2O containing two valence electron pairs resulting in the oxidation of hydrogen atoms. Second example is CH_4 : Carbon has received four electrons from hydrogens and is thus reduced. For CO_2 carbon has given for electrons so that it is oxidized. In $PO_4C_3H_3$ (phosphate, which is the key molecule in metabolism) phosphorus has given 5 electrons and thus oxidized. naïvely would expect that P tends to receive three electrons since this is the number of electrons lacking from the higher electron shell of P .
3. Electron pairs appearing in valence bonds are in general much less active than lonely electrons appearing in the highest electron shell. Molecules or atoms containing unpaired electrons are known as radicals. Molecular oxygen $O_2 = O - O$ crucial for cell respiration contains two unpaired electrons and is stable free radical. It reacts with carbo-hydrates, fats, and proteins and helps to liberate metabolic energy which goes to ATP.

Cellular respiration, which can be seen as a reversal of the photosynthesis, is a stunningly complex process consisting of 4 basic steps.

1. At the first step glucose is converted into pyruvate in glycolysis (see <http://tinyurl.com/4rokah6>) [I21] in cytosol. The free energy is released in this process as NADH and ATP. The process requires 2 ATPs as a fuel and produces 4 ATP molecules so that the net gain is 2 ATP molecules. Also 2 NADH molecules carrying metabolic energy are formed. This step precedes also anaerobic respiration.
2. At the next step pyruvate breakdown (pyruvate decarboxylation) in mitochondrion to acetyl-CoA (see <http://tinyurl.com/2wye673>) [I1]. This produces one molecule of NADH and one molecule of CO_2 , which could be seen as waste product.
3. Acetyl-CoA goes through Krebs cycle (see <http://tinyurl.com/hp9go>) [L131]. This process is an oxidation of Acetyl-CoA producing CO_2 and H_2O as “wastes”. In this process the oxygen brought by blood circulation is utilized. In the process NAD is reduced to NADH (see <http://tinyurl.com/2wfrpxj>) [I28] meaning formation of electron pair. Note that NAD and NADH contain two phosphate molecules, which appearing also in ATP.
4. Oxidative phosphorylation via electron transport chain (see <http://tinyurl.com/77zzmakj>) [I15] is the next step in the process. It is electrons rather than electron pairs that are transported in this chain. They are produced in the oxidization of water. In this process ADP receives one phosphate molecule transforming to ATP is the next step in the process. Cytochrome c oxidase (see <http://tinyurl.com/yab2oymh>) [I12] is also involved with the process. O_2 receives four electrons from cytochrome c molecule and is thus oxidized. O_2 then combines with four protons to form two H_2O molecules. Cytochrome c receives its electrons from four NADH molecules transforming to NAD^+ ions. Electron transport chain is involved also with the photosynthesis (see <http://tinyurl.com/r3f6k>).

The change in the membrane potential induces the transfer of 4 protons through membrane and the Coulomb energy liberated in this process drives the F_0F_1 machine acting somewhat like a turbine of a power plant and generating ATP from $ADP + P_i$ in synthesis of ATP (see <http://tinyurl.com/ya5hn5j8>) [I5].

Photosynthesis

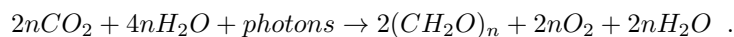
Photosynthesis (see <http://tinyurl.com/r3f6k>) [I38] is performed in plants and algae and interpreted as a process extracting metabolic energy from solar radiation. In the presence of electron donor photosynthesis generates from carbon dioxide CO_2 and photons carbohydrates and oxidized donor. The process consists of two sub-processes: the process extracting the energy needed to drive the process and the process storing solar energy to chemical energy carried by a carbohydrate polymer (sugar).

1. The general equation for photosynthesis is in a schematic form given by



One could say that DH_2 molecules gives its two hydrogen atoms for the carbohydrate and receives oxygen atom from CO_2 molecule in the process. In the initial state the electron donor D is reduced by the two electrons from H_2 . In the final state D is oxidized since it has donated two electrons to O . The elementary step if the process involves two CO_2 and DH_2 molecules and involves the transfer of four protons and electrons.

2. In oxygenic (as opposed to anaerobic) photosynthesis DH_2 is replaced with water molecule. The equation is now however slightly different



The process produces oxygen from carbon di-oxide whereas cell respiration does the opposite.

3. Water can be supplied by some other compound. For instance, arsenite molecule AsO_3^{3-} can replace water:



Photosynthesis takes place in two steps.

1. In the first step light-dependent reactions or light reactions capture the energy of light and store it temporarily to ATP and ADPH molecules.
2. In the second step light-independent reactions store part of the energy of ATP and NADPH to the chemical energy of sugar molecules. This step involves the capture and reduction of carbon dioxide to produce also oxygen necessary for the cellular respiration. The energy stored to the carbohydrates serves as metabolic energy to be used in the cell respiration to generate ATP and NADPH.

This short overall description of course gives only a very rough overall view about extremely complex process. A more detailed description is given in Wikipedia article (see <http://tinyurl.com/r3f6k>) [I38], where also excellent illustrations about the process can be found.

Photosynthesis is performed by plants and algae and involves photosynthetic membranes and organelles known as chloroplasts (see <http://tinyurl.com/dmhoa>) [I10].

1. Chloroplasts capture the light energy and store it to ATP and NADPH in a complex process known as photosynthesis. Chloroplasts contain pigment molecules such as chlorophyll (see <http://tinyurl.com/ycx7nk3>) [I9], carotene and xanthophyll. Chlorophyll gives plant leaf their green color since these wave lengths are not absorbed by the chlorophyll molecules.
2. Chlorophyll molecules contain so called antenna proteins giving rise to a light harvesting complex which absorbs photons from the incoming radiation. The light energy from the antenna proteins is transferred to chlorophyll molecules. Chlorophyll molecules are arranged in and around photosystems embedded in thylakoid membranes of chloroplast.

3. There are two photosystems in which photon absorption takes place: P680 and P700. They are named after the wavelength at which the absorption of light is maximum (680 *resp.* 700 nm).

Photosynthesis gathers the energy needed to drive it from the radiation. In light-dependent reactions that ATP and ADPH needed to drive light dependent reactions are formed. In light-independent reactions part of the energy of ATP and ADPH is stored as the chemical storage as CO_2 is reduced to sugar carrying the energy. Only this part of the process is visible in the general equation for the photosynthesis.

1. Light-dependent reactions

Light dependent reactions (see <http://tinyurl.com/ya6ynsxj>) [I27] take place in the thylakoid membranes of chloroplasts (see <http://tinyurl.com/dmhoa>) [I10].

1. There are four protein complexes known as photosystem I and II, cytochrome bf_6 complex, and ATP synthase. The first two absorb the photons and donate the resulting energetic electrons. The third generates ATP and fourth ADPH in a sequences of reduction processes generated by electron known as electron transport chain (see <http://tinyurl.com/77zzmak>) [I15]. One can imagine that electron falls down along stairs and loses energy at each step received eventually by ATP and NADPH.
2. What happens that chlorophyll molecule in photosystem II absorbs photon and gives one electron in an excited state with higher energy. The electron is highly unstable and flow through electron transport chain and end up to photosystem I where it absorbs another photon. The final electron acceptor is NADP which transforms to NADPH as it receives proton and electron.
3. Proton gradient over the cell membrane appears as in cell respiration and is used to generate ATP molecule during the first step. The process is catalyzed by ATP synthase also now. Chlorophyll molecule regains the lost electron from water molecule in photolysis releasing O_2 molecule. Also now 2 water molecules and 2 chlorophyll molecules are involved. 4 protons are released in the oxidation of the water molecule.

The so called Z scheme (see <http://tinyurl.com/ybrf248k>) [I38] describes how the light-dependent reactions are thought to occur in thylakoid membranes (see <http://tinyurl.com/7rx984r>) of the chloroplasts to synthesize ATP and NADPH driving the light-independent reactions storing part of the energy of photons chemically to the energy of sugar molecules.

1. Oxygen evolving complex (see <http://tinyurl.com/ycldzc83>) [I38] is not well understood. What this complex does is oxidation of two water molecules to O_2 and 4 protons and 4 electrons. They replace the lost electrons of two chlorophyll molecules. Photosystem II is the enzyme that catalyzes the oxidation of water leading to a production of O_2 and for protons and electrons. What happens in the oxidation of water molecules might relate closely to the TGD inspired proposal that $ATP \rightarrow ADP + P_i$ process involves a reconnection of a flux tubes with hydrogen bond flux tube connecting two water molecules.

The resulting four electrons which are given to the chlorophyll a molecules to compensate the electrons that they have lost. The four protons are later used to transform $NADP^+$ —obtained when electron originating from chlorophyll is absorbed by NADP to NADPH.

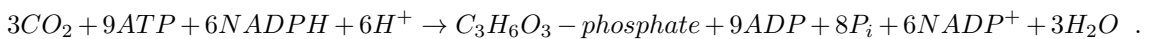
2. In photosystem II the electron in chlorophyll a molecule is excited to a higher energy state by photon absorption. The electron is highly unstable and goes down along electron transport chain losing energy produces ATP. Does the production of ATP proceed just as in the case of cell respiration. Four protons, four electrons and one O_2 molecule These would be produced in the first step of the process. One half of the products of the process splitting water molecules would produce ATP and one half would produce....
3. The electron ends down to the photosystem II where it absorbs second photon and goes down to second electron transport chain to be finally absorbed by NADP molecule. $NADP^+$ absorbs proton produced in the oxygen evolving complex to give NADPH. ATP and NADPH drive the electron transport chains.

4. The process must return O_2 molecule and four protons and electrons to two water molecules and this indeed takes place when ATP and ADP are used. Thus the net effect of the oxidation and reduction of water would be generation of sugar binding the energy of photons to metabolic energy.

It would seem that the pairing of dark electrons occurs when the photons are absorbed by NADP ADP. This would suggest that paired dark electrons appear ADP, P, and NADP. At this stage electrons are not paired. Pairing would occur only when ADP and ATP and carbohydrate are formed.

2. Light-independent reactions

In light-independent reactions the enzyme RuBisCO captures CO_2 from atmosphere and in process required the newly formed NADPH, known as Calvin-Benson cycle (see <http://tinyurl.com/y1bcy63>) [17], releases there carbon sugars, which are later combined to form sucrose and starch. The overall reaction is



Note that 9 ATP molecules and 6 NADPH energy carrying molecules produced by light dependent reaction are used to drive the overall reaction. The sugars are used to build cellulose, and precursors of lipid and amino-acid synthesis or as a fuel of cellular respiration.

8.4 TGD Inspired View About Metabolism

The notions of negentropic entanglement, dark matter as phases with non-standard value of (effective) Planck constant, high T_c electronic super-conductivity, and dark protons providing representation of genetic code, are the basic building bricks in TGD based quantum model of living matter. This picture leads also to a quantum model of metabolism having deeper interpretation in terms of a transfer of negentropic entanglement (NE). For quantal aspects of metabolism evidence has been accumulating since 2007 [118].

The deepest question about metabolism is “Why metabolism?”. The thermodynamics based answer is that it means transfer of ordered energy dissipated in the organism. This might be however only partial truth as already discussed. The real answer suggested by NMP and already discussed is that metabolism is responsible for the transfer of NE to the system and energy transfer is more like side effect.

The following represents the view about metabolism as it was for few years ago. This view is by no means meant to be a list of truths carved in stone. The more recent ideas such as the distinction between short range NE and long range NE and the possible transformation of these two kinds of NEs to each other have been already discussed.

The question whether nutrients carry long range NE or short range NE is open. The older vision discussed below assumed that nutrients carry short range NE in the scale of nutrient molecules. In [K88] the proposal that nutrients carry long range NE with dark matter part of Mother Earth is discussed. It is however important to realize that both of these NEs are in principle possible for nutrients that flux tubes carrying long range NE could serve as effective stores of short range NE. There is evidence that even electrons can serve as nutrients: this conforms with the idea that electron as a negentropically entangled pair of two wormhole contacts could carry almost 127 bits of negentropy.

As already explained, there is now some indirect evidence for the existence of the dark Earth [K111] as a spherical layer of dark matter with radius with total mass of order $10^{-4}M_E$, which is same as the radius of Moon’s orbit. It might be possible to resolve these conundrums by a careful analysis of what is known about ATP-ADP process but also a new bright idea might be needed.

8.4.1 Negentropic Entanglement And Covalent Bond

The great idea is that living matter resides in the intersection real and p-adic worlds- in the intersection of matter and cognition. This would among other things mean that entanglement

probabilities are rational or quantum rational.

p-Adic physics leads to the notion of negentropic entanglement possible when entanglement probabilities are rational or quantum rational numbers [K84] (which belong to algebraic extension of rationals by p : th root of unity). One can ask why entanglement probabilities should be restricted in this manner. In non-generic case this is certainly not true. The answer is that Negentropy Maximization Principle [K73] takes care that system ends up to a situation when entanglement is rational or quantum rational.

The natural question is how the quantum rational entanglement is realized in living matter. The basic characteristic of quantum rational entanglement is that it is stable with respect to NMP just as bound state entanglement. It seems however un-necessary to assume that negentropic entanglement reduces to a bound state entanglement so that one could assign binding energy to it. This suggests that the somewhat fuzzy notion of high energy phosphate bond corresponds to negentropic entanglement and indeed carries what might be called negative binding energy.

This vision leads to the idea that energy metabolism is basically needed for a redistribution of negentropic entanglement and the model for DNA as topological quantum computer leads to a model of $ADP + P_i \rightarrow ATP$ process as a process generating magnetic flux tube connection between two systems A and B by reconnecting two flux tubes short-circuited to water molecules. This short-circuit would take place by a reconnection with a magnetic flux tube assigned with a hydrogen bond (see <http://tinyurl.com/4vvzj>) [I24]. One might interpret this process as assigning to this particular flux tube the negentropy associated with ATP and other molecular nodes associated with the flux tube connection. This assignment might be regarded as information transfer.

Are large \hbar electron pairs in covalent bonds of bio-molecules responsible for negentropic entanglement?

In what degrees of freedom the negentropic entanglement distinguishing biomolecules from the ordinary ones resides? A little thinking leads to a rather obvious first guess. This vision is consistent with other visions about how living matter manages to be a macroscopic quantum system.

1. The only degrees of freedom one can imagine are electronic. The carriers of negentropic entanglement would be paired electrons assignable to covalent bonds. These pairs need not be ordinary spin 0 electron pairs appearing in molecules in vitro which are expected to be able to have only entropic entanglement. Whether the entanglement is assignable to the electrons of the pairs or to pairs of pairs, remains open at this moment, although the latter option is much more attractive.
2. This pairing of electrons is very similar to the formation of Cooper pairs and could be seen as a super-conductivity in atomic or molecular scale. Therefore one obtains a connection with the hypothesis that living matter is high T_c super-conductor [K23].
3. The hierarchy of Planck constants suggests another manner to realize living matter as a super-conductor. This suggests that the outer valence electrons can topologically condense to space-time sheets with non-standard value of Planck constant. As a matter fact, this hypothesis was introduced as the first application of the hierarchy of Planck constants in order to explain the claimed strange properties of so called ORMEs suggesting strongly super-conductivity at room temperature [K23]. These electron pairs were associated with outer shells of atoms. TGD inspired model for high T_c super-conductivity indeed assumes that Cooper pairs correspond to a non-standard value of Cooper pairs but did not yet identify them as valence electron pairs [K23]. Not that a high T_c super conductor Cooper pairs are however formed from unpaired valence electrons (one in the case of copper).

The challenge is to show that negentropic entanglement is possible only for non-standard values of Planck constant characterized by integer - call it n : the number theoretically inspired guess is that the p-adic prime characterizing the quantum rationals involved with negentropic entanglement is a factor of n .

This would mean that three different ways to see living matter as a macroscopic quantum system in TGD Universe would be equivalent. If this picture is accepted, one ends up with a very general vision.

1. All covalent bonds of bio-molecules can be in negentropic state. For their organic counterparts covalent bonds are expected to carry ordinary spin zero electron pairs with entropic entanglement.
2. Negentropic entanglement requires in the most general situation that entanglement probabilities are algebraic numbers and rational entanglement corresponds to the simplest situation. Quantum arithmetic generalization of the notion of rational number however is however the p-adically favored option. Also quantum rational entanglement is negentropic and characterized by prime p . The following argument suggests that negentropic entanglement requires non-standard value of Planck constant.

It would not be too surprising that the entanglement probabilities were proportional to $1/n$, where n characterizes the Planck constant so that negative entropy would be possible only when p is a factor of n . The two ways to have macroscopic quantum coherence - negentropic entanglement and large \hbar - would not be independent mechanisms but different facets of one and the same mechanism. For $n = 1$ only ordinary entropic entanglement would be possible so that ordinary chemistry would be entropic.

3. How the value of the p-adic prime p characterizing the negentropic entanglement in quantum arithmetics correlates with the value of Planck constant? Could the integer defining \hbar have p as a factor so that the p-adic prime p and the value of \hbar would correlate? Are prime values of n favored?
4. Paired valence electrons would be negentropically entangled. What can one say about the character of this entanglement?
 - (a) For ordinary molecules these electrons pair to spin 0 state. For high T_c super-conductivity electron pairs have spin 1 [K23], and suggest themselves strongly also now.
 - (b) For spin singlet states the entanglement probabilities in spin degrees of freedom are uniquely fixed and equal to $P = 1/2$. For spin 1 states only the state with vanishing spin projection is entangled and the mixing with spin 0 state could give rise to two unentangled states. Therefore negentropic entanglement in spin degrees freedom is not a plausible source of negentropy and it should therefore be between electron pairs. Also the fact that entanglement should generate long range correlations between distance bio-molecules, suggests the same.
 - (c) The $1/p$ -proportionality of the entanglement probabilities for $p > 2$ requires that the entangled degrees of freedom are not spin degrees of freedom so that entanglement between spatial wave functions remain. The simplest situation involves p state pairs. This however not the only possibility. Even two states is enough. The naïve guess is that the n -sheeted character of space-time region gives rise to n -fold degeneracy of states so that entanglement involves sum over n state-pairs and factor $1/n$ emerges naturally.

Is the number of covalent electron pairs maximized in living matter?

If the negentropic entanglement is between electron pairs, the amount of negentropy would depend on the number of electron pairs and one would expect that this number them. This would mean also maximization of the density of Cooper pairs. Also the assumption that the entanglement is between electron pairs favors maximization of the covalent bonds since this maximizes the quantum coherence by magnetic flux tubes. Does this maximization take place in living matter?

1. Carbon and silicon tend maximize the number of covalent bonds since they have maximum number of valence electrons. Glucose (see <http://tinyurl.com/b25mu>) has the chemical formula $C_6H_{12}O_6$ is the basic metabolite and maximizes the number of valence electron pairs per Carbon atom: this number is four. Hence glucose could be interpreted as an optimal carrier of negentropic entanglement.

2. Phosphate is the basic building brick of metabolism. Phosphate having the chemical formula PO_4H_3 is so called oxidation state. Although the formal valence of phosphorus is -3 it behaves in phosphate with valence 5 so that the number of valence electron pairs is as high as 8!

Even more interestingly, quite recently it has been found evidence that oil droplets can be regarded as a primitive life form. The TGD inspired model [L13] [K49, K50] led to the identification of the counterpart of the phosphate as nitroglycerin (see <http://tinyurl.com/y9a23qen>) [I31], which is also an oxidation state maximizing the number of electron pairs.

Also arsenic based life (see <http://tinyurl.com/krg3bs>) [I25] has been suggested and there are even indications for its realization. Arsenic is analogous to phosphorus has been proposed as possible counterpart of phosphorus.

3. Each nucleotide of DNA strand contains phosphate group giving it high negentropy and also *A, T, C, G* have rather high negentropy. For *A* the number of electron pairs is maximal-24- and *G* comes next. This might explain why just ATP defines the standard metabolic currency. Note that also GTP (see <http://tinyurl.com/y8ns4mv3>) is used as a source of metabolic energy in protein synthesis.
4. Peptides are often called information molecules and are also known to correlate strongly with emotions and emotional expression so that they have been called molecules of emotion [J29]. Peptides as amino-acid sequences as also hormones, neurotransmitters, hallucinogens, alcohols and other neuro-chemicals contain a large number of covalent electron pairs. This would support the view that the excretion of hormones and all similar compounds is basically a process of sending flux tubes connecting the sender of the signal with the target by negentropic entanglement. The binding of the chemical to the corresponding receptor would build the entanglement bridge having magnetic flux tube as a correlate.

It would be natural to assign to the generation negentropic entanglement positive emotional coloring and negative emotional coloring to its reduction. The re-distribution of negentropic entanglement *d* between biomolecules using metabolic activities could therefore give rise to emotions with both colorings.

There are several questions to be answered.

1. Atomic electrons are at overlapping atomic orbitals but what about spin 1 super-conducting valence electron pairs with large \hbar ? Could it be that these electrons reside in a region where the Coulomb forces by atoms associated with the valence bond compensate each other so that the electron pair sees very small force. Could this make the de-localized electron pairs effectively free? Could the large value of Planck constant provide them the ability to control the distance of the composite atoms?
2. Can one understand high energy phosphate bond from negentropy maximization? Negentropic entanglement could bind particles without binding energy. This of course need not be always the case but could one assign to the electron pairs of phosphate negative binding energy? This negative binding energy could be caused by the Coulomb repulsion between the electron pairs and the stability of phosphate would be due to the negentropic entanglement between the pairs.
3. H_2S (see <http://tinyurl.com/ybeo6sy>) is used as a nutrient by some groups bacteria. H_2S is oxidized just as water. Are the electron pairs of H_2S ordinary or dark? At what step they are transformed to dark electrons if this they are ordinary in H_2S ? Is this transformation a phase transition induced by the presence of the analog of Cooper pair Bose-Einstein condensate (the mechanism would be the analog of stimulated emission). Could this be tested experimentally?

To sum up, the proposed hypothesis could unify three different hypothesis about the origin of macroscopic quantum coherence. The hypothesis that living matter is high T_c electronic super-conductor, the hypothesis that negentropic entanglement is the basic characteristic of living matter, and the hypothesis that dark matter corresponds to a hierarchy of Planck constants realized in terms of effective multi-sheetedness of the embedding space.

What is the exact role of the solar radiation?

Photons provide the energy in photosynthesis. Do photons also provide negentropic entanglement or only make possible to re-distribute negentropic entanglement? Since the negentropic entanglement is a non-local 2-particle property rather single particle property, the idea that photons would carry negentropic entanglement does not make sense. This would support the minimal assumption that solar photons provide the metabolic energy needed to re-distribute the entanglement: this indeed requires destruction and reconstruction of highly energetic valence bonds. Of course, this energy could be also realized as a mechanical work.

Large \hbar photons should in question. Are they generated by a phase transition increasing the value of \hbar at relevant magnetic body? What level in the onion-like hierarchy of magnetic bodies this magnetic body corresponds to? Is the magnetic body of the antenna proteins in question? Or is it some higher layer in the hierarchical structure of the magnetic body? Do the photons appear with several values of Planck constant?

How do dark protons and dark electrons relate?

One of the key observations leading to the identification of dark matter as a large \hbar phase was the effective chemical formula $H_{1.5}O$ for water in atto-second time scales [K45]. The explanation was that 1/4: th of protons are dark in this time scale. The portion of dark photons is expected to depend on temperature and pressure and would make water a two-phase system effectively. This could explain the numerous anomalies of water in the temperature range 0-100 C [K45]. In living matter the portion of dark protons could be even higher.

This hypothesis led later to the idea that dark protons form dark nuclei and to the completely unexpected observation that the quantum states of dark protons are in natural correspondence with DNA, RNA, tRNA, and amino-acid molecules and that vertebrate genetic code finds a natural realization [L3, K58]. The fundamental realization of genetic codes would be at the level of dark nuclei consisting of dark proton strings connected by color flux tubes just as ordinary nuclei in TGD inspired model of nuclei. Taking this seriously, one is forced to conclude that also dark protons play a crucial role in living matter. They indeed appear in key role in both photosynthesis and cellular respiration. The challenge is to understand the precise mechanisms involved.

1. The number of both protons and electrons participating to a typical process step is $n = 4$. The oxidation of two water molecules gives O_2 molecule and 4 protons and electrons. Is the reason for number four just this or could four protons form a dark nucleus serving as a counterpart of 4He , which has exceptionally high binding energy. This sequence corresponds to a sequence of four DNA codons. Do this kind of sequences have a special role?
2. One could counter-argue that the high binding energy of 4He like state would require additional binding energy requiring additional metabolic resources. A possible resolution of the problem would be negentropic entanglement allowing binding without binding energy. This would allow also longer dark nuclei proposed to accompany DNA, RNA, and amino-acids. If dark 4-proton nuclear strings are there, could they be associated with pairs of water molecules and could hydrogen bonds accompany them and serve as their signature? Could the appearance of 4 protons in $ADP + P_i \rightarrow ATP$ process involves a reconnection of the flux tube with hydrogen bond and transfer of 4-proton dark nucleus through the mitochondrial membrane?
3. A natural question is whether also dark nuclei give rise to magnetic flux tubes giving rise to macroscopic quantum coherence. DNA double strand has very high electronic charge of two units per nucleotide assignable to the negatively charged phosphate groups. This creates problems with the stability.
 - (a) Could this charge be stabilized by dark protons forming long dark nuclear strings? This would give unit positive charge per single nucleotide which is more favorable concerning stability. Could one have one dark proton per single nucleotide with a 1-1-correspondence between the state of the nucleotide and DNA so that genetic code would be realized? Nucleotides and their conjugates in DNA double strand are connected by

hydrogen bonds. Could the long dark proton strings possibly accompanying DNA and its conjugate relate with these hydrogen bonds?

- (b) Could the dark protons have spins parallel to the DNA strand and generate the magnetic flux tubes around which the DNA strands are formed? Are also other mRNA and amino-acids formed around magnetic flux tubes generated by dark proton string?
4. The condition that the Compton length of dark proton is of order the length of DNA associated with single nucleotide (about 1 nm) would fix the value of \hbar associated with the dark protons to be about 10^6 . For this value of the Planck constant electronic Compton length would be around 1 micrometer which is the size scale of cell nucleus. Is this a mere coincidence? In fact, the condition that dark electrons and protons appear with Planck constants giving rise to approximately same Compton lengths gives rise to a hierarchy of Planck constants in powers of integer near to the mass ratio $m_p/m_e \sim 2^{11}$ postulated in the original version of dark matter hierarchy but given up latter.

Empirical evidence for quantum coherence

Since 2007 empirical evidence for the importance of macroscopic quantum phases and quantum entanglement in photosynthesis has been accumulating and provides support for electronic bio-super-conductivity suggested already two decades ago.

1. The group led by Graham Fleming [I118] provided evidence for quantum coherence in light-harvesting proteins of green sulphur bacteria. The experiments were however carried out at 77 K so that one could not exclude the possibility that the effect is due to the low temperature.
2. The group led Graham Fleming 2010 has found evidence for quantum entanglement (see <http://tinyurl.com/2g7smd>) [I43] at room temperature and in much longer length scales than expected. This is against the prediction of the standard quantum theory that quantum entanglement is extremely fragile and destroyed by thermal fluctuations. The new physics explanation would be naturally as entanglement of large \hbar structures for which the length scale of entanglement would be scaled up and the energies associated with the bonds would be still above the thermal threshold. Photons with the energies of visible light and having wave lengths even in EEG range [K44, K96] are indeed basic building brick of TGD based view about living matter.
3. 2010 the group led by Elisabetta Collini (see <http://tinyurl.com/yftuca8>) [I40] found similar evidence in light-harvesting protein found in cryptophyte algae at physiological temperatures. The second finding was that the rate at which the oscillations of a coherent superposition of two electron excitations with different energies lasted about 400 fs whereas the expectation was 100 fs. The naïve guess would be that the value of Planck constant was by a factor 4 larger than its standard value.
4. Greg Scholes (see <http://tinyurl.com/ygjt71k>) [I18] irradiated in his experiment the antenna proteins of marine algae at room temperature by two laser pulses lasting for about 10^{-12} seconds to induce single electron excitations with slightly different energies. This created effectively two oscillating dipoles whose electric fields were superposed. Immediately after laser beam was sent through the antenna protein system. The study of the changes in the laser beam due to the interference with the electric field generated by the electronic excitations demonstrated that the energy patterns of distant molecules fluctuated in a way revealing correlation between them. The phenomenon observed was quantum beat (see <http://tinyurl.com/yd643tck>) [B1], a quantum version of the low frequency oscillation observed when two tuning forks with slightly different frequencies are hit simultaneously. Quantum beat demonstrated that the two electronic excitations generated by the laser pulses were non-local and superposed with each other.

These experiments provide the strongest support hitherto that the harvesting the photons in photosynthesis are macroscopically quantum coherent structures in electronic degrees of freedom. The measurements demonstrate the linear superposition for electronic excitations

with different energies. Not only single molecule would be excited but a superposition of electronic excitations localized at different molecules would be generated. This would help to explain the extremely low losses of photon energy in the process. The energy would be routed from antenna proteins to nearby reaction-center proteins. Instead of choosing one classical path the electrons are transported simultaneously along all paths and every-time the shortest path will be chosen eventually.

A superposition of electronic excitations at different locations for the condensate by single photon would be in question. Visible photon wave length sets the scale in question to be at least of the order of micron (the size scale of cell nucleus). For a non-standard value of Planck constant the scale would be longer. The following picture applying quite generally rather than only in the case of antenna proteins suggests itself.

1. By their small mass electrons obey very fast dynamics and adapt to the conformational dynamics of molecules. Single electron cannot affect the conformational dynamics but acting quantum coherently together electron pairs can control the protein dynamics by collective phase transitions.
2. Magnetic flux tubes would accompany spin 1 electron pairs replacing valence electron pairs and would give rise to macroscopic quantum coherence and correlations at the level of molecules. This is more or less the original proposal made for almost two decades ago [K23, K24]. The new elements are the hierarchy of Planck constants and the identification of Cooper pair like states as valence electron pairs with spin 1. The dipole magnetic fields generated by spin 1 electron pairs make possible the web of magnetic flux tubes along which supra currents can run.
3. This could be also the mechanism of high T_c super-conductivity. Magnetic flux tubes are key players also in TGD inspired model for high T_c super-conductivity [K23] explaining the observed two critical temperatures in terms of percolation process: a phase transition in which relatively short flux tubes emerge below the first critical temperature but cannot give rise to a macroscopic super-conductivity. At lower critical temperature these flux tubes reconnect to form longer flux tubes and in this manner make possible macroscopic super-conductivity [K23]. Reconnection would be the fundamental mechanism also in high T_c super-conductivity. It should be possible to test the predicted spin 1 property of electron pairs and in the case of high T_c super-conductivity the spin 1 character has been established.
4. The interpretation in terms of a Bose-Einstein condensate of non-localized electron pairs would be a natural first guess. In this case all electron pairs would be in same state and quantum entanglement need not be present. A better guess is indeed entanglement between electron pairs at the ends of flux tubes. Whether this kind of entanglement plays a role also in high T_c super-conductivity is an interesting question.

8.4.2 Questions About Metabolism

Adenosine-tri-phosphate (ATP) is usually seen as a universal energy currency molecule of cell (for excellent popular article see [I3]). ATP is critical for all forms of life. ATP is involved with transport work (e.g. the transport of molecules along micro-tubuli) and mechanical work (muscle contraction and movement of flagellae and chromosomes). The major role of ATP is usually believed to be related to chemical work. ATP serves also as a switch: by bonding to a protein and receiving or giving phosphate to a protein ATP molecule can induce a conformational change of protein leading to its activation or inactivation.

The basic processes involved are charging and discharging of the ADP molecule by phosphorylation and its reverse process (according to standard view: TGD view is somewhat different). Many aspects of the ATP functioning are far from being completely understood and there are real mysteries, if not paradoxes, involved. One of them is how the process inducing ATP mediated energy transfer is accompanied by momentum transfer giving rise to a coherent locomotion. This suggest strongly quantum coherence of the process.

The TGD inspired vision allows to see the basic purpose of metabolism as a re-distribution of quantum information realized as negentropic entanglement between sender and receiver and this

allows to see also ATP from a new viewpoint. Macroscopic quantum coherence is indeed the basic aspect of the process in this picture. In this framework energy metabolism might be seen as a pre-requisite for the re-distribution of bridges of negentropic entanglement.

ADP → ATP as a reconnection process?

The interpretation of $ADP + P_i \rightarrow ATP$ as a reconnection process is the genuinely new element in TGD view about metabolism. The reason is that this process is essentially non-local modifying the connectedness structure of the web formed by the magnetic flux tubes. As opposed to this, metabolism is purely local process in the standard view.

1. ADP → ATP could be regarded as a reconnection machine creating reconnections between various systems and in this manner re-organizing the connectedness structure of the magnetic flux tube web. Flux tubes from systems A and B going through ADP and P_i short-cut to water molecules a and b would reconnect with the mediation of ATP molecule creating connection between A and B.

O= would be in a special role since flux tubes connect at least these. Why? A possible explanation comes from the observation that the flux tube pair associated with O= gives rise to a representation of genetic codons by the total spins of two electron pairs associated with the flux tubes. Also the directions of magnetic fields associated with the flux tubes provide this kind of representation.

2. Suppose that hydrogen bonds are accompanied by flux tubes. Note that this flux tubes need not be short. Magnetic flux tubes can reconnect with the flux tubes associated with hydrogen bonds. In the initial situation: ADP is connected to system A by a flux tube and P_i to system B by a flux tube and in ATP state ATP fuses the two connections to single one.

There are two O=: s assignable to the ends of the flux tube. The flux tubes from A and B can short cut to water molecules and one obtains A-OH and B-OH connections and splitting of A-B connection. Formation of ATP is a reversal of this process. OH from water molecule a and H from water molecule b “eaten” and part of connection created between systems A and B. What remains is water molecule getting OH from and H from a.

3. What it means for the flux tube end to the water molecules? Is the negentropic entanglement (NE) present? This is possible since OH carries a dark electron pair located near OH. One could speak about macroscopic quantum phase formed by dark water molecules. If O= flux tube pairs are correlates for directed attention, one could say that water molecule is target of attention [K3].
4. Is an oxidation process involving two water molecules and producing 4 protons and electrons accompanied by the above described process involving flux tubes?
5. The communication of sensory data from the cell membrane to the magnetic body is a key element of TGD based model of living matter and EEG and its variants are involved with these communications [K44] ? This communication would naturally involve NE . Can one have a NE between the ends of the flux tubes with length scales which is astrophysical? Do the flux tubes return back to some other organism or organism itself? Or could electron pairs at the ends of flux tubes located in distant magnetosphere outside Earth be important? I have indeed proposed that the magnetic body of entire Earth is relevant for consciousness and life and there is intriguing indications that this might be the case [K66].

Generalized form of second law and metabolism

The non-determinism of state function reduction gives automatically rise to the ensemble entropy so that NMP implies second law of the entanglement is ordinary entropic entanglement. What happens in the case of NE : does the notion of ensemble fail now?

NE makes possible a generation of genuine negentropy locally. This is not possible in standard physics where the optimal situation means vanishing negentropy and entropy when entanglement is reduced in state function reduction process. TGD based form of second law predicts

that second law holds true for zero energy states only above the time scale characterizing the CD geometry defined by temporal distance between the tips of the CD.

How the second law generalizes? Could it be that negentropic entanglement breaks the second law? In any case, second law in time scales larger than the scale of CD would be natural since one must introduce ensemble to describe the situation but does it follow when also NE is allowed?

The pessimistic generalization of second law states that the generation of NE is always accompanied by a process generating a compensating entropic entanglement. There is no rigorous justification for this proposal and it might be wrong. On the other hand, if this generalization holds true, one should be able to identify the process generating the compensating entropy in metabolism.

Consider first what happens in the generation of ATP trying to think in terms of transfer of NE - its re-distribution - rather than in terms of metabolic energy.

1. Generation of ATP creates connection and NE between distant molecules and uses one molecule of water as a hydration process. One cannot say that the negentropy of water molecule is transferred to the high energy phosphate bond. Rather the entanglement in the final state is between two molecules A and B connected by flux tubes going through the ATP. Before the generation of ATP there were two flux tubes connecting A and B to water molecules. Metabolic energy would be basically used to realize re-distribution of NE ? The reverse process can be regarded as dehydration and one molecule of H_2O is used.
2. In phosphorylation the splitting $ATP \rightarrow ADP + P_i$ producing intermediate P_i would not occur but ADP is produced. P_i and high energy negentropic bond would be transferred to the phosphorylated molecule. It could be enzyme which is activated in this manner so that the redistribution of NE would be essential for the bio-catalysis. The phosphate P_i would be attached to the second end of a flux tube. Reconnection process inducing the transfer of entanglement would take place so that negentropic A-B entanglement would transform to A-C entanglement.
3. $ATP \rightarrow ADP + P_i$ liberates energy.
 - (a) Is the NE lost and transformed to entropic entanglement as the connection splits or is the NE only transformed to a different form?
 - (b) In the splitting short-cut of flux tube connections to water molecules happens as their reconnect with hydrogen bond. This would split the connection A-B to A-water and water-A connection. Does it make sense to speak about NE between water molecule and molecules at the end of the connection?
 - (c) The valence electron pair associated with O-H valence bond would entangle negentropically with that of molecule A/B. This process reduces the connectedness of the web formed by magnetic flux tubes: does this mean generation of entropy?

Consider next how the second law in the pessimistic form could be realized in metabolism suggested by the fact that living matter seems to be very effective polluter of environment.

1. In cellular respiration CO_2 and H_2O are regarded as “wastes”. Could this mean that the electron pairs possibly having large \hbar and spin 1 lose their flux tube connection to the organism? And could the lack of flux tube connection induce a transformation to ordinary spin 0 valence electron pair at least in the case of CO_2 ?
2. In photo-synthesis O_2 molecules are regarded as the “wastes”. They have only one valence electron pair and several unpaired electrons. Same hold true for O_2^- super-oxide molecules. Both are free radicals and highly reactive causing oxidative stress (see <http://tinyurl.com/33sevk>) [I34] inducing damage to DNA. This in turn correlates with degenerative diseases, cancer, and senescence. Could this be interpreted as an entropic effect? Is the damage to DNA caused by the transformation of high \hbar electrons to ordinary ones and their pairing with ordinary electrons so that super-conducting phase suffers damage inducing a further damage

at molecular level as the magnetic body loses NE and its controlling abilities weaken? Could it be possible to “heal” the damaged super-conducting phase?

If the second law in the pessimistic form is behind the effect it could be cured only by guiding the unavoidable entropy production to take place outside body.

TGD inspired questions about photosynthesis

The basic assumption is tht hiving matter is high T_c super-conductor [K23].

1. Spin 1 electron pairs with negentropic entanglement generate magnetic flux tube structures and long range coherence. These spin 1 pairs give rise to high T_c superconductivity by creating the magnetic flux tubes as the routes along which they propagate. If they have energy higher than spin 0 pairs they decay to these and magnetic flux tube structures disappear and therefore also super-conductivity.
2. Electrons and electron pairs control the conformations by their very fast adaptive dynamics. Macroscopic quantum coherence would induce macroscopic quantum coherence of this dynamics. The challenge is to preserve the macroscopic coherence for which a geometric correlate is defined by long magnetic flux tubes.
3. There is considerable evidence for quantum coherent electron transport (see <http://tinyurl.com/yaqdyupe>) [I118]? The electronic excitations are not local but superpositions of excitation located even in separate chromophores. This would suggest electronic excitations affecting the Cooper pairs of entire Bose-Einstein condensate. The decay of a Cooper pair defined by a spin 1 pair of valence electrons looks like a natural mechanism. A defect in super-conductor would be created. “Correlated protein environments” and “correlation between protein induced fluctuations in the transition energy of two neighboring chromophores” are the terms used. Magnetic flux tubes accompanying electron pairs with parallel spins along flux tubes would give rise to these environments and correlated fluctuations.
4. If one believes that a single electron process is in question, dark electron pair could be destroyed in the absorption of dark photon. This is consistent with non-locality of the electronic excitations since non-locality requires that dark electron pair absorbs the photon.

This rough picture raises further questions about the details of the photosynthesis.

1. Suppose that the photons form Sun are ordinary ones so that the presence of the dark magnetic body at some level of hierarchy induces the phase transition of solar photons to large \hbar photons. In the geometric picture this phase transition would correspond to a leakage of photon to a magnetic flux tube at the dark sector of the embedding space. Does the leakage at the level of antenna proteins or already earlier? Or at the magnetic flux tube associated with the chlorophyll’s electron kicked to a higher energy state? Does this kicking split valence electron pair.
2. At what step the dark excited electrons combine to form spin 1 pairs again? Does this take place in the formation of ATP and ADPH and in the generation of sugar molecule? The maximization of the number of valence bonds is an empirical fact and suggests that all valence electron pairs of bio-active molecules are dark spin 1 pairs.
3. Could denaturation (see <http://tinyurl.com/yw2vuo>) [I13] of bio-polymers transform dark valence electron pairs to spin 0 pairs with standard value of Planck constant. Could something like this happen also for the possible dark protons assigned to the basic building bricks of the bio-polymer in denaturation process?

Could this proposal be tested experimentally?

- (a) The parallel spins of pairs give rise to net spin compensated by opposite orbital angular momentum. Is this kind of angular momentum present in living DNA and protein molecules and does it disappear in denaturation?

- (b) Are also water molecules of cellular water dark? If this is not the case, the oxidation process splitting water molecules to O_2 , 4 protons, and 4 electrons should induce a phase transition producing dark electrons and protons. Could large \hbar characterize the valence electron pairs of the “living” portion of water and could the presence of this dark fraction relate directly to water memory and effective $H_{1.5}O$ formula in atto-second time scale?
- (c) How water memory for which evidence is accumulating [K58] relates to electronic and protonic negentropic entanglement?

There are also questions not directly related to the electron pairs.

1. In photosystem II the 4 electrons are provided by the oxidation of water catalyzed by P680 molecule. What happens in this process? Do the 4 protons produced in the splitting of water form dark nucleus analogous to 4He but having charge 4, which the decays to 4 dark protons received by $NADP^-$. What would transform the protons to dark protons. How this phase transition is catalyzed by P680 molecule? Does it provide the presence of embedding space sector with large \hbar to which protons leak and possibly also fuse to form a dark nucleus? Or is the sector present and P680 only provide the energy needed to jump over the potential wall for the ordinary protons.
2. At which step the transfer between different space-time sheets creating or liberating zero point kinetic energy takes place for electrons and protons? Oxidative process or $ADP + P_i \rightarrow ATP$ giving out one water molecule. The P-O-P bond should contain the surplus energy and electron pair should reside be at a smaller space-time sheet at this bond. The dropping of the pair to a larger space-time sheet could destroy the bond which is stabilized by the negative Coulomb energy due to the interaction of the pair with ionized atoms at the ends of the bond.

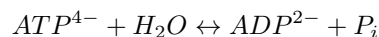
8.4.3 Hydrolysis Of ATP In TGD Universe

The generation of phosphate polymers and polymers in general occurs by dehydration which quite generally seems to involve dropping of a proton to larger space-time sheet and liberation of metabolic energy quantum. In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant \hbar_{eff} so that cyclotron energy would be liberated. In the following early version of the model assigning metabolic energy quantum to the dropping of protons is considered. In [K94] a model of metabolism associating the metabolic energy quantum to the change of cyclotron energy is discussed.

It is interesting to find how one could understand these processes in TGD framework. Since the notion of wormhole magnetic flux tube playing a central role in the model of DNA as topological quantum computer and in the model of bio-catalysis, it is natural to look whether the basic steps of these processes could be understood in this conceptual framework.

1. $ATP \rightarrow ADP$ process

AMP, ADP, ATP are phosphorylated RNA nucleosides [I3] and the hydrolysis of ATP to ADP [I4] plays a key role in the metabolism. Obviously also the molecules XMP, X=U, C, G are important biologically. Each PO_3 in ATP corresponds to one unit of negative charge except for the last one which carries two units of negative charge. According to the standard chemistry $ATP \leftrightarrow ADP$ corresponds to the hydrolysis



where P_i denotes orthophosphate HPO_4^{-2} . In ADP the last phosphate group is $HO-PO_2^{-2}$ rather than $O = PO_2^{-2}$ as in case of ATP.

The actual process is however much more complex than this.

1. The process involves several steps such that energy is liberated in two steps in which the change of Gibbs free energy is $\Delta G = .42$ eV and $\Delta G = .31$ eV making altogether .73 eV, which should closely relate to the liberated metabolic energy.
2. Three protons are accelerated in electric field during the generation of ATP. The interpretation would be in terms of driving of electrons from larger space-time sheet to $k = 137$ atomic space-time sheet. If the larger space-time sheet corresponds to $k = 139$, the increment of the zero point kinetic energy of proton is $(1 - 1/4) \times E_0(137) = .375$ eV for $E_0(137) = .5$ eV of metabolic energy quantum. Three protons would give net zero point kinetic energy increment of 1.125 eV which is higher than $\Delta G_{tot} = .73$ eV. The explanation of the discrepancy should relate to Coulombic binding energy of protons with ATP and F_1 . This interpretation conforms with the observation that the liberated energy is higher for the third proton. It must be emphasized that one can imagine several alternative explanations.

Consider now a more detailed model for the process. The binding of ATP to the catalytic site involves several steps.

Step 1: The binding $ATP + F_1 \rightarrow ATP \cdot F_1$ to the catalyst site is a complex process involving the break-up of the hydrogen bonds between cellular water and ATP molecule and cell water and catalyst site and generation of hydrogen bonds between catalyst site and ATP molecule. In TGD framework this means that protons can be kicked to and dropped back from atomic space-time sheets. Only the net number of protons dropped however matters.

This process involves liberation of Gibbs free energy about $\Delta G_{ATP} = .42$ eV. It was earlier believed that this energy is liberated instantaneously but the findings about the behavior of the F_1 motor coupled to dissipative load, lead Oster and Wang to suggest that the process is more complex and starts from a loose binding and ending up to a strong binding [?].

Step 2 Hydrolysis: $F_1 \cdot ATP \rightarrow F_1 \cdot ADP \cdot P_i$. The change of free energy is small during this step: $\Delta G \sim 0$.

Step 3: Orthophosphate is released from the catalyst site: $F_1 \cdot ADP \cdot P_i \rightarrow F_1 \cdot ADP + P_i$. Free energy $\Delta G \sim .31$ eV is liberated at this step.

Step 4: ADP is released from the catalyst site: $F_1 \cdot ADP + P_i \rightarrow F_1 + ADP + P_i$. $\Delta G \sim 0$ holds true also for this process.

This picture suggests that the notion of the high energy phosphate bond is not quite correct as suggested also by some empirical findings [D44, D29], [I130]. The metabolic energy would be stored as the zero point kinetic energy of protons rather than in phosphate bonds. Perhaps the fundamental function of phosphates would be to make DNA and RNA polymers charged in turn making possible the formation of wormhole magnetic flux tubes and braiding making possible a wide repertoire of catalytic actions.

2. Model of $ATP \rightarrow ADP$ based on wormhole magnetic flux tubes

Consider first the basic philosophy behind model.

1. In the model of DNA as topological quantum computer *XMPs*, $X = A, T, C, G$ can be connected to oxygen atoms by wormhole magnetic flux tubes having quark and antiquark at opposite throats of wormhole contact and charge conjugated quark-anti-quark pairs at the ends of the flux tubes. Dark u quark and its charge conjugate code for A, T and d quark and its conjugate for G, C so that the conjugation for nucleotides corresponds to charge conjugation for quarks and $A - G$ and $T - C$ symmetries of the third nucleotide of the codon to isospin symmetry.
2. Basic bio-catalytic processes are identified as a reconnection of the wormhole magnetic flux tubes and change of the length of the flux tube induced by the change of the value of Planck constant associated with it. It would not be too surprising if this kind of mechanism were involved also in $ATP \rightarrow ADP + P_i$. The reason for the special role of ATP among *XTP* might be that the positive charge $q(u) = 2/3$ of u -quark maximizes the attractive interaction between u quark and phosphate.

3. Flux tubes connect to oxygen atoms in the proposed model of bio-catalysis and protein folding [K7]. The model relies on ideas inspired by the model of DNA as topological quantum computer [K3]. In this model hydrogen bonds are assumed to correspond or to be accompanied by (wormhole) magnetic flux tubes. Also flux tubes connecting acceptor atoms or molecules of hydrogen bonds are assumed to be connected long flux tubes and represent genuinely new physics. Examples of acceptors are $O =$ atoms in phosphates and amino-acids and aromatic rings in DNA and also in some amino-acids. The model for protein folding has tight connections with existing chemistry and leads to a very simple and successful criterion for the formation of hydrogen bond between $N - H$ and $O =$ in the constant part of amino-acid and to a successful proposal for the folding code.
4. DNA as TQC model gives further constraints. The structure of the phospholipids suggest that in the case DNA nucleotides long flux tubes connect the aromatic ring of the nucleotide to the $O =$ atom at the hydrophilic end of the lipid acting as a standard plug which in turn can be connected to another acceptor and eventually terminates to a donor of hydrogen bond. The detailed charge structure of the aromatic ring(s) should determine the quark-nucleotide correspondence. The connection line to the lipid could involve several intermediate $O =$ plugs and the first plug in the series would be the $O =$ atom of the monophosphate of the nucleotide. Not surprisingly, phosphorylation would be absolutely essential for the operation of DNA as topological quantum computer. $O = -O =$ flux tubes could also act as switches inducing a shortcut of the flux tube connection by reconnecting with a hydrogen bond connecting two water molecules. This is an essential step in the model for how DNA acts as topological quantum computer.

A possible model (perhaps the simplest one found hitherto) for the reaction $ATP \rightarrow ADP + P_i$ is based on the assumption that it splits a flux tube connection defining strand of a braid defining topological quantum computation. A change of the hardware of topological quantum computer would be therefore in question.

1. Suppose that ATP defines a standard plug in flux tube connections. This would mean that aromatic ring and the oxygen atoms $O =_1$, $O =_2$, and $O =_3$ of the phosphates are connected by magnetic flux tubes to a string and $O =_3$ in turn is connected to some (hydrogen bond) acceptor elsewhere, say $O =$ or aromatic ring. These flux tubes represent genuinely new physics in accordance with the fact that “high energy phosphate bonds” are not really understood in the standard chemistry.
2. The reconnection of $(O =_2) - (O =_3)$ flux tube with the hydrogen bond connecting two water molecules leads to the splitting of the flux tube so that the incoming and outgoing flux tubes are shortcut by $(O =_2) - -H - (OH)$ resp. $(O =_3) - -H - (OH)$ hydrogen bonds (connection to ground is the analog in circuit theory). This corresponds in the usual terminology the liberation of the third phosphate: $ATP \rightarrow ADP + P_i$. P_i however remains at the end of flux tube to be attached later to another ADP.
3. The process involves also hydration. $(OH)^-$ ion joins to the third P to give P_i^{-3} and H^+ to $O - P$ in second P to give $H^+ - O$ in ADP^{-1} . The exchange of electron would lead to the final state $ADP^{-2} + P_i^{-2}$.

A possible model for the dropping of protons would be following.

1. It is absolutely essential to realize that F_1 is an open system and that naïve thermodynamic considerations can lead to misunderstandings. In particular, the notion of high energy phosphate bond does not make sense. The source of metabolic energy is chemical energy used to drive protons to the atomic space-time sheets of F_1 . The function of the large negative charge of ATP is to increase the rate for the binding of ATP^{-4} to F_1 . In the classical picture the binding to F_1 is followed by the dropping of two protons to larger space-time sheet. The value of the metabolic quantum could be reduced from .5 eV to about .21 eV by the Coulombic interaction energy of proton with PO_4^{4-} . The Coulombic binding energy of the remaining protons at F_1 with $ADP + P_i$ is smaller and the dropped proton liberates larger energy about .31 eV. In quantum picture the division of the process to this kind of sequence might not be a good approximation.

2. One function of the $ATP \rightarrow ADP$ would be to induce the dropping of the third proton from F_1 space-time sheet. Metabolic energy should make possible information processing. Second function might indeed relate to the topological quantum computation like process since the decay would correspond to a splitting of a braid strand coming to the aromatic ring of A and proceeding along string defined by the ring and three $O =: s$ of phosphates and continuing further. This would make possible TQC as a braiding for both halves of the split flux tubes. After the reconnection the total braid structure would be different.
3. The reason for why P_i leaves the catalyst site and proton is dropped (step 2) should be the in-stabilization of the bound state of positively charged proton with $ADP^{-2} + P_i^{-2}$ which does not have so strong Coulomb interaction energy with proton as ATP^{-4} . As a consequence, proton can drop to the larger space-time sheet.
4. What remains open are the details of the transformation of the chemical energy to zero point kinetic energy of protons. Remote metabolism suggests that protons send negative energy phase conjugate photons to the direction of geometric past inducing a transition of an energy carrying molecule to a lower energy state. This would mean the failure of the standard description in terms of reaction kinetics. The catabolism of nutrients is the eventual provider of the metabolic energy and the coenzyme nicotinamid adenine dinucleotide NAD^+ [I29] receives electron and the energy liberated in the catabolic reaction. In the proposed framework it is not an surprising that NAD^+ is analogous to RNA dinucleotide (perhaps as remnant from RNA era when dinucleotides defined the 2-codon code) and consists of two phosphates and adenine and nicotinamide nucleosides. The oxidation reaction $NADH \rightarrow NAD^+$ in turn liberates this energy. Protons could gain their energy by sending negative energy photons to $NADH$. Negative energy photons would propagate along “topological light rays” parallel to the flux tubes connecting the system in a precisely targeted manner to $NADH$ aromatic rings. Alfvén waves propagating along magnetic field lines would be the standard electrodynamics counterpart for these topological light rays.

Many details of the process remain open but it would seem that the key ideas of TGD based quantum vision about living matter are fused together in rather detailed manner in this picture.

8.4.4 Could High Energy Phosphate Bond Be Negentropic Bond With Negative Binding Energy?

Most people assign the word “love” to the word “life” as their first association. There is a notable exception to this: scientists including biologists. Un-educated layman might however wonder whether one can understand life without identifying any physical counterpart for this notion (, which could be replaced with that of compassion, sex, or ability to act synergetically or just X if some of these notions sounds less un-scientific). Certainly the word “love” stimulates a deep feeling of disgust in a reductionistically conditioned scientist. But isn’t the duty of scientist to win this kind of feelings and try to see whether this identification might be possible after all? The prize could be high: the understanding of what distinguishes between living and dead matter could change the entire culture. Who knows, maybe it could be possible to identify some poorly understood fundamental biological process allowing a quantitative model using a guess for what this physical correlate could be. The basic step of metabolism is at the core of life and indeed poorly understood, and I shall argue that the identification of the negentropic entanglement as the counterpart for the notion of love could allow to model quantitatively what happens in this process.

Basic ideas

Before continuing general motivating comments about implications of negentropic entanglement (see **Fig.** <http://tgdtheory.fi/appfigures/cat.jpg> or **Fig. ??** in the appendix of this book) are in order.

1. Ordinary bound states are stable because they have positive binding energy. One can visualize this kind of binding as a jail: the second particle resides near the bottom of a potential well.

Organized marriage is a social analogy for this situation. Negentropic entanglement makes possible bound states for which binding energy can have and perhaps even has always a wrong sign. The state is not prevented from decaying to free particles in state function reduction by energy conservation: Negentropy Maximization Principle (NMP) [K73] takes care that they remain correlated. The social analogy would be a voluntary marriage based on love. Partners are completely free to leave but want to stay together. One implication could be explanation for the stability of highly charged basic molecules of life such as DNA and ATP.

2. The presence of the negentropic entanglement implies the directedness of the biological processes since the outcome of the state function reduction would be far from random since the behavior of negentropic bonds could be almost deterministic. In the case of time-like entanglement this would select only particular initial final state pairs so that determinism would emerge also in this sense and could lead to almost deterministic irreversible cellular automaton behavior characteristic for the living matter very different from the reversible determinism of classical physics and very difficult to understand in quantum context.
3. The determinism would of course be only partial and would allow volition not spoiled by randomness of quantum jump. This would provide a general explanation for the ability of the living matter to overcome the second law basically implied by quantum randomness predicted by the standard quantum theory. This would happen in time scales shorter than the time scale of the appropriate causal diamond (CD) only but one would have hierarchy of CD meaning that in arbitrary long time scales there are levels of hierarchy at which second law is broken. The hierarchy of Planck constants would be also crucial since it would allow zooming up to arbitrarily long time scale. Non-equilibrium thermodynamics and cellular automaton models could be seen as phenomenological descriptions for the actual breaking of second law in the intersection of real and p-adic worlds.
4. High energy negentropic bonds need not be present only in phosphates. O=s are present in all important biomolecules. Phosphates are present in DNA. Each peptide bond in amino-acid polymer contains O=. Also sugars contain it. Maybe O= indeed acts as a universal plug defining then ends of negentropic flux tube bonds between biomolecules. For instance, protein folding for which a possible model is discussed in [K7] from different view point could be more or less deterministic cellular automaton like process if the bonds are negentropic. Negentropic entanglement would also guarantee the stability of the folding pattern. Certainly the assumption that the process is random -as standard quantum theory would suggest- leads to Levinthal paradox stating that the rate of the process is quite too slow. The simplest possibility is that the flux tube bonds are between O=s of subsequent amino-acids before folding and the folding process involves formation of reconnections possibly drawing by a reduction of Planck constant certain amino-acids near to each other. O=s could also act as plugs connecting protein to other biomolecules. One must however notice that many neurotransmitters, hallucinogens, and alcohol having strong effects on consciousness have O-H groups instead of O=s. This inspires the question what happens to the flux tube in $O=\leftrightarrow O-H$ process.

General formulation of the model

Consider now the model. High energy phosphate bond (see <http://tinyurl.com/yar7zv7j>) [I22] assigned with the two outer-most phosphates of ATP (see <http://tinyurl.com/clnu4>) [I3] is fundamental for the basic processes in living matter. The $ATP \rightarrow ADP + P_i$ liberates metabolic energy loaded to ATP in the cellular respiration process (see <http://tinyurl.com/yyvrpb>) [I8] or its equivalent and occurs again and again and defines a kind of Karma's cycle in living matter. The phosphate bond is assumed to have a high energy content liberated as ATP is hydrated to ADP (see <http://tinyurl.com/5w7cud>) [I2] and phosphate ion (see <http://tinyurl.com/2xbv3y>) $P_i = PO_4^{3-}$ [I35]. The notion of high energy phosphate bond has been however challenged as being meaningless [D44, D29], [I130].

1. One can of course consider a high energy bond for which the interaction potential looks like a well at the top of mountain and spin glass degeneracy of quantum TGD would certainly allow

to consider this kind of notion. I do not know whether models realizing this idea concretely have been really constructed.

2. My earlier proposal for $ATP \rightarrow ADP + P_i$ process is inspired by the notion of many-sheeted space-time and p-adic length scale hypothesis making sense in the intersection of real and p-adic worlds and involves the dropping of protons (or electrons) to larger space-time sheets and driven back in oxidative metabolism. The energy liberated in this process corresponds to the zero point kinetic energy of protons (or electrons), which is smaller at the larger space-time sheet. The maximum value of zero point kinetic energy is predicted to be $E_0 \simeq .5$ eV for $k = 137$ in the case of proton and for $k = 148$ in the case of electron (for electron the energy would be by a factor $2^{-11}m_p/m_e \simeq .94$ smaller).

In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant \hbar_{eff} so that cyclotron energy would be liberated. In the following only the “dropping” option is discussed.

3. With an inspiration coming from DNA as topological quantum computer model [K3] I have also proposed that the magnetic flux tubes connecting bio-molecules to each other define a kind of Indra’s net plays a key role in the biological information processing. For instance, topological quantum computations could be realized in terms of braids formed by flux tubes [K3, K7]. O=: s associated with phosphates would serve as universal plugs to which flux tubes could be connected connecting intronic nucleotides and lipid layers of nuclear or cell membrane. In particular, the innermost O= of ATP could be connected by a flux tube to any biomolecule needing metabolic energy- say some catalyst or the F_1 machine central for energy metabolism. The reduction of Planck constant would bring ATP and biomolecule near each other and lead to a formation of a weakly bound state making catalytic processes possible. The outer O=: s of the ATP molecule could be connected by a flux tube to each other, which could be rather long loop. This flux tube could provide the new physics realization of the high energy phosphate bond.
4. ATP (P_i) has 4 (3) units of negative charge and at least ordinary layman might wonder why this does not induce instability. Similar problem is encountered in the case of DNA, which contains two units of negative charge per nucleotide. This particular problem is regarded as completely real. The idea about life as something in the intersection of real and p-adic worlds [K101] raises the question whether these high energy states could be made possible by the presence of negentropic bonds- most naturally associated with the flux tubes with large \hbar . This love marriage would stabilize ATP , ADP , and DNA and other charged biomolecules. The presence of phosphates would be a clear-cut signature of this stabilization mechanism. Also proteins involve phosphates playing a key role in the bio-control: typically phosphorylation activates or de-activates the protein and is also involved with the generation of signal pathways. Why this happens would be easy to understand in Indra’s net model.
5. In $ATP \rightarrow ADP + P_i$ transformation the energy carried by the negentropic bonds would be liberated but leave the flux tube bonds negentropic. Cell respiration would take care of the loading of the batteries with negentropic metabolic energy. This would involve also the kicking of protons back to the smaller space-time sheets. Also the molecular lovers ADP and P_i would find each other again as the Planck constant for the flux tube connecting them would be reduced during the cellular respiration transform ADP and P_i back to ATP .

Quantitative estimates

Consider now a more detailed model for $ATP \rightarrow ADP + P_i$. The binding of ATP to the catalytic site involves several steps. I have described them in the previous section and in the following add to this template the interpretation suggested by the proposed picture.

1. **Step 1** : The binding $ATP + F_1 \rightarrow ATP \cdot F_1$ to the catalyst site is a complex process involving the break-up of the hydrogen bonds between cellular water and ATP molecule and cell water and catalyst site and generation of hydrogen bonds between catalyst site and ATP molecule. In TGD framework this means that protons can be kicked to and dropped back from atomic space-time sheets. Only the net number of protons dropped however matters.

This process involves a liberation of Gibbs free energy per single attachment, which is about $\Delta g_{ATP} = .42$ eV. It was earlier believed that this energy is liberated instantaneously but the findings about the behavior of the F_1 motor coupled to dissipative load, lead Oster and Wang to suggest that the process is more complex and starts from a loose binding and ending up to a strong binding [?].

Comment: One can question the assumption that strong binding is generated. Instead of binding proton or electron would be dropped to a larger space-time sheet and liberate zero point kinetic energy.

- (a) The simplest interpretation in the proposed picture is that the negentropic flux tube connecting ATP and F_1 molecule and behaving as high energy phosphate bond associated with the innermost O= is contracted via the reduction of Planck constant. Then proton is dropped from $k = 137$ space-time sheet to a much larger space-time sheet and liberates metabolic energy quantum $E(137) \simeq .5$ eV. Another possibility is that electron at $k = 148$ space-time sheet is dropped. This process would replace the instantaneous generation of binding energy and in zero energy ontology the time scale for this process would correspond to the time scale of appropriate causal diamond (CD).
- (b) Instead of single particle energy macroscopic Gibbs energy $G = E + PV - TS$ is the useful notion now since macroscopic quantities of matter are studied and pressures and temperature are typically constant in the situations considered ($dG = -SdT + VdP$). G is minimized for constant T and P prevailing in the situation considered.
- (c) In the attachment of ATP to catalyst S is reduced and a good guess is that volume is not affected so that PV term does not change. From this one can deduce that the liberated energy per catalyst particle -call it $\Delta e = e_i - e_f = \Delta g - T\Delta s$ (i and f refer to initial and final states) satisfies $\Delta e > \Delta g = .42$ eV.
- (d) One must estimate the value of Δe . The attachment reduces the kinetic energy of relative motion of catalyst and ATP to zero. If it makes sense to speak about thermal equilibrium for ATP an catalyst in translational degrees of freedom the reduction of kinetic energy is $\Delta e_K = 3T/2$, which is of order .045 eV at room temperature. Whether this energy remains in the catalyst-ATP system or is it liberated in the process is not clear. The energy liberated in the dropping of the proton or electron gives a contribution $\Delta e = E_0 = .5$ eV. This gives the condition

$$\Delta g_1 = E_0 + 3T/2 - T\Delta s = .42 \text{ eV} . \quad (8.4.1)$$

If the liberated kinetic energy remains in the system, the first guess is $\Delta e = E_0 = .5$ eV, where E_0 is the nominal value of zero point kinetic energy. This would give for $T\Delta s$ the estimate $T\Delta s = .08$ eV about 3 times thermal energy corresponding to three translational degrees of freedom. This looks rather reasonable order of magnitude estimate.

- (e) NMP suggests-maybe even requires- that the bond remains negentropic. The binding energy associated with ATP- catalyst binding could be small- of the order of thermal energy about .045 eV.
2. **Step 2** Hydrolysis: $F_1 \cdot ATP \rightarrow F_1 \cdot ADP \cdot P_i$. The change of free energy is small during this step: $\Delta G \sim 0$.

Comment: The simplest option explaining the fact that the change of energy is small is that hydrolysis leaves the flux tube between outer $O=$: s of ATP intact and removes only the P-O-P bond. This flux loop could have rather large \hbar .

3. **Step 3** : Ortophosphate is released from the catalyst site: $F_1 \cdot ADP \cdot P_i \rightarrow F_1 \cdot ADP + P_i$. Free energy $\Delta G \sim .31$ eV is liberated at this step.

Comment: The simplest option is that the negentropic flux tube liberates its energy but remains negentropic. The increase of Planck constant might be involved.

- (a) The value of Δe is now smaller than ΔG , which suggests that the metabolic energy quantum in the case of proton corresponds to $\Delta e = E(139) \simeq .25$ eV. The average change of kinetic energy can be assumed to be equal to thermal energy in final state and is same as above. This gives the condition

$$\Delta g_2 = E_0/2 - 3T/2 + T\Delta s = .32 \text{ eV} .$$

- (b) By adding this equation with the similar equation for Step 1 (see Eq. 8.4.1) one obtains the condition

$$\Delta g_1 + \Delta g_2 = 3E_0/2 = .74 \text{ eV} .$$

This gives $E_0 = .49$ eV so that the model seems to be internally consistent.

4. **Step 4** : ADP is released from the catalyst site: $F_1 \cdot ADP + P_i \rightarrow F_1 + ADP + P_i$. $\Delta G \sim 0$ holds true also for this process.

Comment: \hbar increases back to the original value for the innermost flux tube which could it still have small positive energy and be negentropic.

The model would predict that ADP and P_i and remain highly correlated (connected by flux tubes) as do also AXP and F_1 . These predictions should be testable by marking ADP and P_i of ATP with the same “color” (say radioactively) and finding whether the colors of ADP and P_i remain the same during the subsequent cycles or whether they mix immediately. These love affairs at molecular level could be modified only by reconnections of flux tubes as also in human relationships. For instance, two ADPs could exchange their P_i s or F_1 s. Negentropic entanglement could guarantee the highly organized and directed nature of basic bio-catalytic processes.

8.4.5 Directed Attention And Metabolism

There must be a connection between metabolism and generation and/or re-arrangement of flux tubes responsible for negentropic entanglement: quantum criticality and hierarchy of Planck constants would also be involved. In the following I try to formulate this gut feeling more precisely.

1. We assign information to self-organization patterns. Energy feed is necessary to build non-trivial self-organization patterns as far from thermal equilibrium states and in this case negentropy is thought of as the deviation of entropy from its maximum value in thermodynamical equilibrium. When a new pattern is generated, the system is driven to criticality (quantum criticality in TGD) so that a new self-organization patterns are generated.
2. The recent, view about NMP means generating entanglement for which one has large number of eigenstates of density matrix of subsystem entangled with second one. The eigenvalues of the density matrix are exactly identical implying that the entanglement probabilities are equal to $p = 1/N$, N integer. This is a very strong condition and requires some kind of criticality. This means also maximal entanglement. For primes dividing N one obtains negentropic entanglement (see **Fig.** <http://tgdtheory.fi/appfigures/cat.jpg> or **Fig.** ?? in the appendix of this book).

3. Intuitively it is clear that a large representative power requires a large number of degenerate states with essentially same physical properties. A natural possibility suggested by the interpretation of hierarchy of effective values of Planck constant and by the failure of the strict determinism of Kähler action is that these degenerate states correspond to particle states localized at different sheets of N -furcation of Kähler action meaning N -branching of preferred extremal. Two systems of this kind can entangle negentropically. Therefore ability to have negentropic entanglement with N -fold degeneracy and $\hbar_{eff} = N\hbar$ would accompany each other: this would give the long-sought precise connection between hierarchy of Planck constants and negentropic entanglement.

Could $\text{ATP} \rightarrow \text{ADP}$ feed to the system only energy making its space-time sheet critical against the generation of N -furcation? This option does not look attractive. The effects of what ATP gives should be something independent of the receiving system. If it is only energy, this is not the case. Could the ability to generate negentropic entanglement in standard manner be the real gift of ATP. Or could $\text{ATP} \rightarrow \text{ADP}$ be responsible for generating directed attention realised in terms of flux tube connections?

1. Generation of directed attention coupling two molecules to single quantum coherent system seems to be the basic operation in living matter. Reconnection of the Indra's web defined by flux tubes as $AC + BD \rightarrow AD + BC$ is the basic process generating attention; now between A and D and B and C . This is actually the fundamental braiding operation and crucial also in topological quantum computation. Could $\text{ATP} \rightarrow \text{ADP}$ generate attention between some system connected to the phosphate of ATP and the system receiving the phosphate?
2. One can build a toy model for what is needed to build a wormhole flux tube connection between systems A and B and thus generate $N = 2$ negentropic entanglement between them. Consider wormhole flux tubes identified as $N = 2$ -furcations giving rise to negentropic entanglement. Make following assumptions. ATP can be regarded as ADP connected to P by small loop-like flux tube L_1 . P is connected to system A by a flux tube. The receiving system B has flux loop L_2 beginning and ending from it. With these assumptions the reconnection process for L_1 and L_2 creates a flux tube connection between A and B and ADP becomes connected with B . The reconnection of ADP-B with phosphate having self-loop creates ATP-B. At the next step B can be connected to system, say, C in the similar manner. The process would continue in this manner building an attention sequence A-B-C-...
3. One can also consider multi-furcations of wormhole flux tubes to get higher even values of N . Two systems connected by flux tubes can negentropically entangle with N sheets of N -furcation being analogous to the different spin states of two entangled spins.
4. Can phosphate bond have varying value of N and \hbar_{eff} by previous argument so that one could speak about evolutionary level of ATP? $N = 2$ and $p = 2$ -adicity would be of course, the simplest possibility. By feeding several phosphate bonds one would obtain 2^N -furcations and Boolean algebra like structures.

This is not the only interpretation of negentropic entanglement that I have considered. In the model for Becker's DC currents (see <http://tinyurl.com/ybnjk9bq>) [L16] I have considered an alternative possibility: in this case metabolic energy feed would excite a negentropically entangled state of cyclotron Bose-Einstein condensate at magnetic flux tube.

8.5 Many-Sheeted Model For Photosynthesis

Photosynthesis is a fundamental metabolic function and a many-sheeted model allows to concretize the general ideas about quantum metabolism. What happens in photosynthesis at the level of energy balance seems to be relatively well-understood [I57, I38] but the detailed molecular mechanisms remain obscure. Several strange features, such as the appearance of electron pairs, suggest that super-conductivity and atomic and molecular Bose-Einstein condensates are involved. p -Adic length scale hypothesis gives very strong quantitative guidelines in the attempt to understand photosynthesis in many-sheeted space-time, and one ends up to a general view about how

Bose-Einstein condensates store metabolic energy as zero point kinetic energy and how this energy is utilized by remote metabolism by generating negative energy MEs. What is so remarkable is that the resulting extremely simple model of photosynthesis is successful both at qualitative and quantitative level.

8.5.1 A Rough Overall View About Photosynthesis

The photosynthesis in eukaryotes occurs in chloroplasts, which are the counterparts of mitochondria in animal cells and contain photosynthetic pigment-protein complexes [I57, I38]. Prokaryotes do not possess chloroplasts and it is believed that chloroplasts are ancient prokaryotes captured by eukaryotic cells. In both cases the crucial structures are membranes.

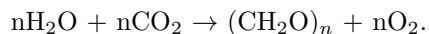
There is an antenna system harvesting photon energy. Antennae are photosensitive pigments sensitive to visible light (400-700 nm). In some bacteria pigments are also sensitive to infrared light in the wave length range 700-1000 nm. The energy is transmitted in electromagnetic form to the so called reaction center. Antenna pigments as well as reaction center pigments are bound to proteins. After the light is transmitted to chlorophylls it excites electron pairs in turn transferred between pigments.

Oxygen producing plants have two photo-systems, photo-system I present also in plants not producing [J75] [I57, I38]. These photo-systems have several tasks to perform.

1. To store the energy of photons permanently to various energy carrying molecules, in particular glucose. Photo-system I takes care of this. Besides hydrogen carbon dioxide serves as the basic raw material of these molecules. The covalent double bonds between carbon and oxygen are reduced in the process. The photons excite in the reaction center of photo-system I electron pairs transferred to NADP^+ to give NADPH which transfers electrons and metabolic energy to where they are needed. Photo-system II draws electron pairs from water and feeds them to the photo-system I to compensate the electrons lost in the generation of NADPH. As water molecules lose two electrons, oxidation happens which means the generation of O_2 molecules. The production of oxygen utilized also by plants themselves is a further basic function of plants.
2. To store photonic energy temporally by transforming ADP molecules to ATP molecules to be used for various purposes. In the photo-system I the electrons can also circulate energizing *one* ADP molecule to ATP per electron pair whereas photo-system II energizes *two* ADP molecules per electron pair to ATP molecule.

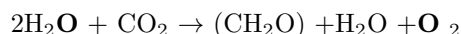
The overall reaction balance equations for photosynthesis deserve a consideration.

1. The overall reaction equation reads as

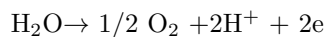


$n = 6$ corresponds to hexoses, in particular glucose, which are the basic products of molecular synthesis and carriers of the metabolic energy.

2. A more precise form of the reaction equation is

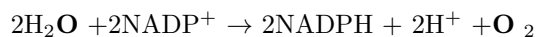


O means that free oxygen derives from water rather than from carbon monoxide which enters to the reaction much later than the oxidation of water. The oxidation of water



indeed happens in photo-system II and provides the electron pair to compensate the electron pair lost by the photo-system I.

3. Hill's equation



tells what happens in photo-system I before CO_2 enters the game. The equation tells that the oxidation of two water molecules providing two electrons and two hydrogen atoms for two NADP^+ ions happens first (for basic facts about NADP molecules see [I30]). NADPH carries then the electrons and hydrogen atoms to the process leading to the formation of say glucose.

8.5.2 A General Model For Energy Storage And Energy Utilization By Remote Metabolism

It is good to formulate first a general model for energy storage and utilization based on remote metabolism.

1. Metabolic energy can be stored as zero point kinetic energy to various space-time sheets. The storing particles form Bose-Einstein condensates so that the energy storage is analogous to a population inversion in laser. Bose-Einstein condensates of electronic Cooper pairs, H atoms, H₂ atoms and protonic Cooper pairs, O and O₂ atoms, ... are possible. The dropping of a particle to a larger space-time sheet liberates a standardized energy quantum. Since Bose-Einstein condensate is in question, this process can occur coherently which allows high metabolic power. Electronic Cooper pairs kicked to $k = k_{ex} < 151$ space-time sheet from $k = 151$ cell membrane space-time sheets are involved with photosynthesis.

In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant \hbar_{eff} so that cyclotron energy would be liberated. In the following only the “dropping” option is discussed.

2. Remote metabolism provides an elegant manner to utilize the stored energy. The user must only send negative energy ME at energy sufficiently near to the energy currency. This implies a highly economical use of the metabolic energy. For instance, when an enzyme needs energy, it generates negative energy ME activating ADP to ATP by kicking proton to the atomic $k = 137$ space-time sheet. In this case .5 eV plus possibly an additional energy .34 eV to kick phosphate ion to $k = 131$ space-time sheet is needed. As already found, the model for the ATP → ADP transformation favors a situation in which space-time sheets involved are linear structures with thickness $L(137)$ and $L(139)$ predicting that the kicking of single proton gives rise to energy .25 eV.

“Seesaw” mechanism minimizes the waste of metabolic energy since the same energy can be used repeatedly [K96]. In the simplest situation two users send repeatedly negative energy MEs for each other and dissipative losses are minimized.

Energy and momentum conservation deserve separate comments.

1. Momentum conservation requires that the kicked particles interact with the Bose-Einstein condensate so that it can receive the momentum of ME. The resulting energy transfer to the condensate is very small, a fraction p/M about the energy of ME.
2. It is of paramount importance to realize that the particles of the Bose Einstein condensate cannot be free. This assumption would lead to contradictions since atomic binding energies are more than order of magnitude larger than metabolic energy quantum. This means that Cooper pairs must possess a binding energy not too far from that possessed the spin-paired valence electrons of water molecule.

Hence the pairs of valence electrons form Bose-Einstein condensates at larger space-time sheets $k = k_{gr}$ are analogous to the de-localized valence electrons in metal. In the excitation of electrons $k_{gr}(i) \rightarrow k_{ex}(i)$, $i = I, II$ the binding energy of electron pair (electron) is not changed appreciably. Also electronic Cooper pairs have their binding energy with Opp system since the nuclear charge is still there, and are de-localized like electrons in metal. Hence there are two separate de-localizations involved and naturally allowed by the many-sheeted space-time. The system is nearest to water if oxygen appears in atomic form.

8.5.3 The General Model For Photosynthesis

The model for the energy storage and utilization by remote metabolism in living matter is stupendously simple and equally simple is the many-sheeted model for photosynthesis resulting as a by-product.

A more detailed model for photosynthesis

The existing ideas about remote metabolism and p-adic length scale hypothesis provide useful hints concerning what happens in the process.

1. The appearance of electrons as pairs is a hint about the presence of electronic super-conductivity.
2. The basic constraint is that single electronic Cooper pair gives rise to single ATP in the case of photo-system I and 2 ATPs for photo-system II. Accepting the proposed model predicting that dropping $k = 137 \rightarrow 139$ of single proton liberates .25 eV and 3 protons drops in single ATP \rightarrow ADP transition, one has that in photo-system I the increment of zero point energy for electronic Cooper pair should correspond to .75 eV at least and in photo-system II to 1.5 eV at least.
3. If the dropping of electron Cooper pairs is the mechanism liberating the zero point kinetic energy in both cases, this gives $k_{gr}(I) = k_{gr}(II) + 1$. Assuming $k_{ex}(i) = k_{gr}(i) - 2$ and the absence of energy losses the conditions $\Delta E_0(e, I) = 3\Delta E_0(p) = .75$ eV and $\Delta E_0(e, II) = 6\Delta E_0(p) = 1.5$ eV give

$$(k_{ex}, k_{gr})(I) = (147, 149) \quad , \quad (k_{ex}, k_{gr})(II) = (146, 148) \quad .$$

For larger values of $k_{gr}(I)$ the metabolic quanta approach to the limits 1 eV and 2 eV.

4. The objection against this model is that single Cooper pair cannot generate to ATP molecules in single stroke. This encourages to consider the option $(k_{ex}, k_{gr})(II) = (148, 151)$ assuming that electron Cooper pairs decay at $k = 148$ space-time sheet and then drop to $k = 151$ space-time sheet. Because one has $\Delta E_0(e, 148) = \Delta E_0(2e, 147)$ and the electrons drop separately, the energy yield is twice that for a Cooper pair. The decay of the Cooper pair would be induced by the absorption of photon naturally since photon energy would be about two times higher than in the case of photo-system I.
5. The most natural p-adic space-time sheets carrying permanent Cooper pair condensates would be $k_{gr}(I) = 151$ giving $\Delta E_{2e} .86$ eV consistent with the upper bound .84 eV liberated as single ATP molecule is used. Same result is obtain in photosystem II. That ground state space-time sheets correspond to different p-adic primes would guarantee that photo-systems I and II are separate even when they have (apparent) spatial overlap.

The model for the effective axonal super-conductivity [K24] supports the view that the BE-condensate residing at $k = 151$ cell membrane space-time sheet is a fundamental electronic Cooper pair BE condensate since the p-adic prime characterizing the fundamental condensate is that for which thermal kicking of Cooper pairs to space-time sheets with smaller p-adic prime are not possible.

A model for the functioning of photo-systems

The previous considerations lead to the following model for the functioning of the photo-systems.

1. The function of the antenna system is to collect energy and store it to chlorophyll molecules by kicking electronic Cooper pairs from $k = k_{gr}(i)$ space-time sheet to $k = k_{ex}(i) < 1$, $i = I, II$ space-time sheets. Antenna pigments could generate MEs transferring the photonic energy to the reaction center as Bose-Einstein condensed photons.

2. Photo-systems II and I act in series. Photo-system II creates oxygen and generates 2 ATP molecules per electron pair whereas photo-system I is responsible for electron transfer and generates NADPH molecules. In the absence of photo-system II it generates only single ATP molecule per electron pair.
3. For both photo-systems chlorophyll acts as a population inverted many-sheeted laser receiving radiation, which inverts the electronic Cooper pair population. Energy storage reduces to the kicking of electrons to $k = k_{ex}(i)$, $i = I, II$, space-time sheet so that they get energy of 1 eV per electron.
4. The primary energy quanta absorbed from the solar radiation differ from the 2 eV and 1 eV energy currencies defined by Cooper pairs and electrons, and one can wonder how the transformation to standardized quanta occurs. Chlorophyll transition is certainly responsible for the absorption of quantum and the whole spectrum of visible light is involved. The question is how the absorbed energy of the chlorophyll is transformed to 2 eV or 1 eV quanta in the population inversion for electronic Cooper pairs. One could guess that the excited chlorophyll system generates ME bridges with energy 2 eV allowing the Cooper pairs to flow from $k = k_{gr}(i)$ to $k = k_{ex}(i)$ space-time sheet, $i = I, II$. In consistency with the seesaw mechanism, this emission would most naturally result from the dropping of electronic Cooper pairs from $k = k_{ex}(i)$ to $k = k_{gr}(i)$ space-time sheets induced by the absorption of photonic energy by chlorophyll.

What happens in the oxidation of the water molecules?

The oxidation of water is perhaps the most mysterious aspect of photosynthesis. The equation $\text{H}_2\text{O} \rightarrow 1/2 \text{O}_2 + 2\text{p} + 2\text{e}$ serves only book-keeping purposes and serious consideration of what might happen generates doubts about whether standard chemistry allows to understand what is involved. Since it is O_2 molecules which are produced, at least two water molecules are needed for the equation to make sense.

This observation suggests that collective effects are of importance, and one is almost unavoidably led to ask whether Bose-Einstein condensates of H, protonic and electronic Cooper pairs, H_2 , O, and O_2 at larger space-time sheets might be involved. If the Bose-Einstein condensates of O_2 and electronic Cooper pairs are involved, situation simplifies dramatically. The model for sol-gel phase transition already led to the tentative idea that Bose-Einstein condensates of hydrogen atoms could be present in the cellular water. Only a small fraction of O_2 , H_2 , H, 2p and 2e would reside at larger space-time sheets. O-, O_2 - and protonic Bose-Einstein condensates might perhaps make water some kind of liquid crystal structure for which electronic Cooper pairs are de-localized like electrons in metal and thus experience the Coulomb force. Also H atoms forming local bound states with O atoms could be de-localized just like valence electrons in the metal lattice.

In this framework oxygen production in photosynthesis could be seen as automatic side product due to the leakage of the O_2 molecules from the system. The sucking of electronic Cooper pairs from the Bose-Einstein condensate associated with water perturbs the critical system and O_2 molecules can be evaporated unless they are utilized by the system itself. The evaporation of O_2 molecules would correspond to the dropping of O_2 molecules to some larger space-time sheet giving at the same time a recoil momentum for the electronic Cooper pair so that it can enter to the reaction center to compensate the excited Cooper pair. The energy in question would be about .0039 eV.

8.5.4 Applying The General Model Of Energy Storage And Utilization To Ionic Pumps

The general model allows also to understand the value of the cell membrane resting potential.

1. The $k = 139$ Bose-Einstein condensate of hydrogen atoms would be responsible for .125 eV energy quantum crucial for sol-gel phase transitions controlled by micro-wave MEs. Also electronic Cooper pairs at $k = 147 = 3 \times 49$ space-time sheet liberate same energy when dropping to larger space-time sheets.

2. H_2 and/or Cooper pairs of protons correspond to energy of .0625 eV (recall that there is small numerical uncertainty involved). Also electrons dropping from $k = 149$ lipid layer space-time sheet liberate this energy. Since the resting potential is .065 eV, this energy is very near to the energy needed/gained by singly charged particle when it traverses cell membrane. The zero point kinetic energy .125 eV of H atoms in turn correspond to the energy needed to carry doubly charged ion such as Mg^{2+} or Ca^{++} through the cell membrane. This leads to the hypothesis that the TGD counterparts of ionic pumps are based on remote metabolism, that is sending of negative energy MEs inducing the dropping of H, H_2 and possibly 2p from $k = 169$ space-time sheet or dropping of electronic Cooper pair from $k = 149$ and electron from $k = 151$ space-time sheet.

8.5.5 Quantum Coherence And Photosynthesis

During years the experimentation to test the presence of quantum effects in living matter has begun. And the positive evidence is accumulating. In Discover magazine there is an article titled *Is Quantum Mechanics Controlling Your Thoughts?* [I148] telling among other things about the latest direct evidence of quantum effects provided by experiments related to photosynthesis.

The article summarizes in popular terms the contents of the paper *Evidence for wavelike energy transfer through quantum coherence in photosynthetic systems* by Fleming and collaborators [I81] reporting evidence for quantum coherence in photosynthesis. The absorption of photon induces electron current from the point of capture- chlorosome- to the reaction centers. The semi-classical theory predicts the dissipation of the electronic energy to be about 20 per cent whereas the observed dissipation is only about 5 per cent. This suggests quantum coherence. The following abstract of the original article summarizes the essentials.

Photosynthetic complexes are exquisitely tuned to capture solar light efficiently, and then transmit the excitation energy to reaction centres, where long term energy storage is initiated. The energy transfer mechanism is often described by semiclassical models that invoke "hopping" of excited-state populations along discrete energy levels. Two-dimensional Fourier transform electronic spectroscopy has mapped these energy levels and their coupling in the FennaMatthewsOlson (FMO) bacteriochlorophyll complex, which is found in green sulphur bacteria and acts as an energy "wire" connecting a large peripheral light-harvesting antenna, the chlorosome, to the reaction centre. The spectroscopic data clearly document the dependence of the dominant energy transport pathways on the spatial properties of the excited-state wave functions of the whole bacteriochlorophyll complex. But the intricate dynamics of quantum coherence, which has no classical analogue, was largely neglected in the analyses even though electronic energy transfer involving oscillatory populations of donors and acceptors was first discussed more than 70 years ago¹¹, and electronic quantum beats arising from quantum coherence in photosynthetic complexes have been predicted and indirectly observed. Here we extend previous two-dimensional electronic spectroscopy investigations of the FMO bacteriochlorophyll complex, and obtain direct evidence for remarkably long-lived electronic quantum coherence playing an important part in energy transfer processes within this system. The quantum coherence manifests itself in characteristic, directly observable quantum beating signals among the excitons within the Chlorobium tepidum FMO complex at 77 K. This wavelike characteristic of the energy transfer within the photosynthetic complex can explain its extreme efficiency, in that it allows the complexes to sample vast areas of phase space to find the most efficient path.

The popular article translates the article to the following piece of text.

To unearth the bacteria's inner workings, the researchers zapped the connective proteins with multiple ultra-fast laser pulses. Over a span of femto seconds, they followed the light energy through the scaffolding to the cellular reaction centers where energy conversion takes place. Then came the revelation: Instead of haphazardly moving from one connective channel to the next, as might be seen in classical physics, energy traveled in several directions at the same time. The researchers theorized that only when the energy had reached the end of the series of connections could an efficient pathway retroactively be found. At that point, the quantum process collapsed, and the electron's energy followed that single, most effective path.

My own interpretation would be following.

1. Remarkably long lived electronic quantum coherence is claimed to be present. Authors propose

that quantum computation like process -quantum random walk [I11] - could be in question. If I have understood correctly, the proposed process can halt only by a state function reduction localizing the electron at the reaction center. Completely standard Schrödinger evolution in the network would be otherwise in question. The good news is that the average time to find from the entrance to exit in this kind of process is exponentially shorter than in the classical random walk. One can say that exit plus all other points are always reached after some minimum time and it is enough to perform the state function reduction localizing the electron to the exit.

2. Somewhat confusingly, the popularizers claim that the authors argue (I do not have access to the original article) that the quantum random walk selects the shortest path from the chlorosome to the reaction center is in question. Quantum collapse is a non-deterministic process and if it selects the path in this particular case it can select any path with some probability, not always the shortest one. The selection of the shortest path is not necessarily needed since the quantum random walk with fixed entrance and exit is by its inherent nature exponentially faster than its classical counterpart. The proposed interpretation makes sense only if the state function reduction takes place immediately after the electron's state function at the exit becomes non-vanishing. Does it? I cannot say.

If one accepts this view, the sole problem is to understand how macroscopic quantum coherence is possible in the length scales considered. There are good arguments supporting the view that this is not the case for the ordinary quantum mechanics. In TGD framework the hierarchy of Planck constants [K47] suggests that both macroscopic quantum coherence and very low dissipation rate are due to the large value of \hbar for electrons. For instance, for $\hbar = 5 \times \hbar_0$ the naïve estimate is that dissipation rate should reduce by a factor 1/5 and coherence times and lengths should increase by a factor 5. I have proposed much larger values of \hbar in the model of living system.

8.5.6 Pollack's mechanism and photosynthesis

An obvious idea is that Pollack's mechanism is the predecessor of photosynthesis [K62] [L44]. The question is therefore whether photosynthesis could involve the formation of exclusion zones (EZs) by the analog of whether photosynthesis could involve the formation of exclusion zones (EZs) by the analog of Pollack's mechanism [L25, ?, ?] (see <http://tinyurl.com/oyhstc2> leading to charge separation taking place also in photosynthesis. Pollack's mechanism creates in presence of radiation and water bounded by a gel at the boundary of water and gel an EZ, which is a layer negatively charged water with effective stoichiometry $H_{1.5}O$ consisting of layers with hexagonal structure. The TGD inspired proposal is that hydrogen bonded pairs of H_2O molecules are formed and that each of them loses one proton as dark proton at magnetic flux tubes outside EZ. The notion of many-sheeted space-time and topological field quantization are essential elements of the proposal. Same phenomenon could be caused also by irradiation by sun light.

The light dependent step $2H_2O \rightarrow 4H^+ + 4e^- + O_2$ of photosynthesis pumps protons through thylakoid membranes (for an illustration see <http://tinyurl.com/ycecu6uf>). The electrons excited by photons of sunlight are transferred along electron transport chain and lose energy used to pump protons through the thylakoid membrane and being thus transferred from stroma to grana against electric gradient. ADP transforms to ATP as these protons return to back through ATP synthase. This step is repeated again and again.

Could dark protons created by the analog of Pollack's mechanism be involved with photosynthesis? In what step the protons are transformed to dark protons by this mechanism?

1. The model of cell membrane leads to a proposal that pumps and channels quite generally are dark magnetic flux tubes and protons (and also other ions) are transferred through them as dark protons (dark ions). This would imply almost dissipationless transfer.
2. The protons are pumped as dark protons through the thylakoid membrane along dark magnetic flux tubes serving as pumps using the energy provided by electrons flowing down in the electron chain. The dark protons return from grana through ATP synthase as dark protons as ATP is generated and transform with some rate back to ordinary protons in stroma. Otherwise the fraction of dark protons would steadily increase.

3. This leaves two options under consideration. Already the step $2H_2O \rightarrow 4H^+ + 4e^- + O_2$ step $2H_2O \rightarrow 4H^+ + 4e^- + O_2$ creates dark protons by a generalization of Pollack's mechanism or this step creates ordinary protons transformed by Pollack's mechanism to dark protons as they are transferred to dark magnetic flux tubes serving as pumps. The first option looks more plausible.

What is interesting is the electron transport chain is involved also with the cellular respiration. There are various light therapies using red or IR light, and they seem to provide basically metabolic energy. Cells would act like plant cells and the analog of photosynthesis could be in question. This would explain the claims that the members of some religious cults can practically live utilizing only sunlight. I have actually proposed that analog of photosynthesis storing the energy by $ADP + P_i \rightarrow ATP$ type process using standard machinery could be actually involved and transfer the energy of IR light to metabolic energy further distributed by ATP.

The metabolic machinery for cellular respiration contains so called oxidative phosphorylation (OP) as a basic step: OP adds to ADP a phosphate giving metabolic currency ATP. ATP in turn distributes the metabolic energy further. OP uses electron transport chain to transfer metabolic energy from NADH by $NADH \rightarrow NAD^+H^+ + 2e^-$. The electrons go through the electron transport chain as in photosynthesis and transfer protons outside the mitochondrial membrane very much like through thylakoid membrane in photosynthesis. The protons return through ATP-synthase and induce $ADP + P_i \rightarrow ATP$.

The metabolic energy must come from somewhere and OP indeed follows Krebs cycle in which the energy is extracted from nutrients and given to the NADP molecule. The photon energy could be fed directly to OP electron transport chain just as photon energy is transferred to this chain in photosynthesis. The presence of electron transport chain is necessary and one must feed the electrons and protons to this chain somehow.

1. Could the analog of photosynthetic reaction $2H_2O \rightarrow 4H^+ + 4e^- + O_2$ with visible photons replaced with IR photons produce dark protons? Whether this is energetically possible and whether the electrons have high enough energies to drive the dark protons through the membrane is far from clear. One can of course imagine, that the number of pumped protons per electron is lower than usually.
2. A mechanism that I have called quantum credit card or remote metabolism [K62] looks more plausible. The splitting $2H_2O \rightarrow 4H^+ + 4e^- + O_2$ could occur - not by absorption of positive energy photon but by emission of negative dark IR photon with the energy of visible photon. Cell would actively suck metabolic energy from IR light source. The emitted dark negative energy IR photon would decay to ordinary IR photons in reverse time direction, which would look like fusion in standard time direction and is thermodynamically non-favoured. ZEO predicting kind of syntropic processes to occur in living matter would be an essential prerequisite.

At deeper level metabolic energy might correspond to negentropic entanglement and thus information. Information could be the basic metabolic currency.

8.5.7 Gut cells without mitochondria can survive: proof for the notion of remote metabolism?

Gut cells without mitochondria can survive (see <http://tinyurl.com/hqq79th>)! There are many other strange findings. Visible and IR light energize human skin cells transferring energy for the cells- the analog of photosynthesis. Some spiritual groups and also traditionally the people called saints are reported to survive by using only sunlight as their source of metabolic energy. NASA has studied sleigh dogs able to run for days without eating and showing no signs of getting tired.

Could photosynthesis work also in animal mitochondrial cells? The basic mechanism could be essentially the same: electron transfer chain providing energy to pump protons through cell membrane against potential gradient. This is the key step of both photosynthesis and cellular respiration. After that protons flow spontaneously back through ATP synthase and liberate energy to build ATP from ADP. This is like power plant. In plants solar photons provide the energy for electrons. In the animal cells dark photons with large $h_{eff} = n \times h$ (transforming now and then to

biophotons) could do it. In the case of IR metabolism electrons could send to the energy source dark negative energy IR photons, which decay to ordinary IR photons. This would be an active variant of metabolism and time reversal of the usual mechanism: I have called it quantum credit card mechanism or remote metabolism [L44](see <http://tinyurl.com/gu3nbnp>).

Now even mitochondria are missing! Could remote metabolism work also without mitochondria? $ADP \rightarrow ATP$ transformation should occur since ATP is the universal energy currency. Could it take place as remote metabolism by sending negative energy photons to the cells having the mitochondria. The electron transfer chain is preceded by Krebs cycle extracting the energy from nutrients: could the absorption of negative energy photons induce the decay of nutrient without transfer of energy to electron chain of the mitochondria. The hungry gut cell without mitochondria would be allowed to eat in the table of the luckier ones. Again one quantum objection against vulgar darwinism. This would be like kicking laser from population reversed state to ground state by phase conjugate negative energy irradiation.

8.6 Metabolic energy and negentropy and chemical qualia as number theoretical qualia?

I had Facebook discussions with biologists James Kohl about metabolism, information, and energy. I agreed with him that the importance of metabolism and nutrition in evolution has been underestimated.

1. It is of course known that metabolism is fundamental but the reason why this should be the case is far from clear. Energy and information are closely related but identifying energy with information proposed by Kohl is of course wrong.
2. The standard thermodynamical explanation is that metabolic energy is ordered energy like work so that metabolic energy is basically information or reduction of entropy from its maximal value. The problem is however that thermodynamics provides only a fundamental definition of entropy, not of information. One can speak of entropy currents reducing local entropy but this is not enough to understand living matter. The belief that life is just a thermodynamical fluctuation is non-sense.
3. Energy feed is certainly the prerequisite of having self-organization but the notion of non-equilibrium thermodynamics is only a phenomenological description. Criticality and even quantum criticality seem to be basic aspects of life but again it seems that neither thermodynamics nor the existing quantum theory is enough.
4. My conviction is that one must have a genuine notion of information and the only genuine information is conscious information. Information is always about something, and information is also relative notion. Bit sequence is information only for a conscious entity for which it has a meaning. Shannon entropy based notion of information fails in these respects. One must identify physical correlates of cognition.

One must extend standard real number based physics describing dead matter but unable to say anything interesting about animate matter. What is required is what I call adelic physics. Number theory would become a new mathematical building brick of physics.

These discussions led to a little discovery about chemical senses having tastes and smells as qualia. The usual belief shared also by me is that they are strictly chemical senses and they indeed might be so but only partially. Taste and smell might actually be number theoretic senses telling about average value of $h_{eff}/h = n$ serving as kind of number theoretic IQ of a biomolecule. We could perceive dark matter by sensing it! Quite generally, qualities like beauty could correlate with the value of n assignable to sensory input. This interpretation relies on progress occurred in the understanding of TGD inspired theory of consciousness and adelic physics so that I will describe the background before discussing the idea.

8.6.1 Brief summary of TGD view about consciousness and quantum biology

In the following I describe first the basic building bricks of the most recent TGD vision about consciousness and quantum biology.

Zero energy ontology

Zero energy ontology (ZEO) replaces the notion of quantum state with zero energy state. It can be regarded as pair of initial and final states of quantum event. At space-time level these events correspond to 3-surfaces at opposite boundaries of causal diamond $CD \times CP_2 \equiv CD$, where causal diamond CD is the intersection of future and past directed light-cones of 4-D Minkowski space M^4 . The conserved quantum numbers of quantum states at opposite boundaries of CD have opposite values.

1. ZEO leads to a modification of quantum measurement theory leading to a theory of consciousness [L58]. Self can be seen as a generalized Zeno effect and corresponds to a sequence of state function reductions leaving everything fixed at second boundary of CD . Self dies and re-incarnates as time-reversed self as the first reduction to the opposite boundary takes place. Negentropy Maximization Principle (NMP) was originally postulated as an independent variational principle of consciousness but it seems that adelic physics implies in statistical sense automatically.
2. Remote metabolism is one of the possible implications of ZEO. System could send negative energy radiation to geometric past (this radiation would correspond to time reversed “radiation self”). If there is a system able to receive this radiation - say population inverted laser, remote metabolism as active gain of metabolic energy becomes possible. Also remote metabolism based on positive energy photons is possible but is passive. Remote metabolism could be in central role in living matter.
3. Motor actions could quite generally involve sending of negative energy radiation to past: this would explain Libet’s finding that volitional action is preceded by neural activity.
4. Also active remote perception by sending radiation to past or future reflected there as radiation with opposite arrow of time becomes possible and could make control and sensory perception possible in arbitrarily long scale: finite light-velocity would not be a problem. One cannot exclude the possibility that what is regarded as hallucinations caused by some psychoactive drugs are actually remote perceptions of this type.

Hierarchy of Planck constants and dark matter

TGD based model relies heavily on the identification of dark matter as a hierarchy of phases labelled by the value of effective Planck constant $\hbar_{eff} = n \times \hbar$.

1. The larger the value of n , the longer the Compton lengths scaling as n . Atomic size scale scales as n^2 . The binding energies of hydrogen atom scale as $1/n^2$ so that the phase transition increasing n and making quantum coherence in larger length scale possible requires energy [K36, K37, K38, K39, K61]. Hydrogen atom is simplest atom and proton transfer reactions are indeed very important. They occur also between bases of DNA base pairs (see <http://tinyurl.com/jxqvkcjb>).

Cyclotron energies are proportional to n and again metabolic energy is required. The phase transitions increasing n take place at quantum criticality: scale up quantum lengths correspond to long range correlations and quantum fluctuations. Living matter would be quantum critical system in which metabolic energy feed makes possible phase transitions increasing the value of n .

2. This picture leads to a model of bio-catalysis in which the temporary reduction of n for atom of catalyst or reactants liberates binding energy kicking reactants over the potential wall so that the reaction can proceed swiftly [K36, K37, K38, K39]. After than the energy could be

returned to the catalyst. In $\text{ATP} \rightarrow \text{ADP}$ the dark atom assignable to high energy phosphate bond would be given to the acceptor molecule. ATP would be created by using ATPsynthase using the energy or protons going through mitochondrial membrane and kicking atom to dark atom state in phosphate attache to ADP. The energy to drive protons through the membrane would basically come from nutrient molecule. The protons would be also dark.

3. There are two quite different ranges of values of n [K36, K37, K38, K39, K88]. Quantum criticality corresponds to a situation in which the perturbative QFT fails. Since em gauge couplings strength is of form $\alpha = Z_1 Z_2 e^2 / 4\pi\hbar c$, perturbation theory can fail for large charge values $Z_1 Z_2$. The phase transition \hbar to $\hbar_{em} = Z_1 Z_2 e^2 / 4\pi v_0$, where $v_0 < c$ has dimensions of velocity, makes perturbation theory possible ($\alpha_{eff} = v_0/c$). Nature is theoretician friendly as one might say. Same applies to color interaction and weak interaction and also to gravitation: gravitational coupling strength GMm can be also very large and the phase transition increasing \hbar to $\hbar_{eff} = \hbar_{gr} = GMm/v_0$. Now the values of \hbar_{eff} are extremely large.
4. If one has $\hbar_{eff} = \hbar_{gr}$ at magnetic flux tubes defining the magnetic body (MB) of the system, the dark cyclotron energy does not depend on the mass of the particle and is universal. The mysterious bio-photons can be identified as ordinary photons resulting in phase transition changing $\hbar_{gr} \rightarrow \hbar_{eff}$ for matter visible to us. The energy spectrum would be in visible and UV and this allows to deduce estimate for the value of \hbar_{gr} . Note that the value of \hbar_{eff} for matter visible to us need not be its smallest value corresponding to $n = 1$. The notion of hydrino atom claimed by Randell Mills with scaled up binding energy suggest $n = 6$ [L38].
5. The overall conclusion is that the organism-environment duality must be generalized to a trinity including also MB carrying dark matter. MB uses biological body as motor instrument and sensory receptor. MB has a hierarchical structure with a wide spectrum of values of \hbar_{eff} . The purely biological level corresponds to flux tubes and atoms $\hbar_{eff} = \hbar_{em}$ and the more spiritual level to $\hbar_{eff} = \hbar_{gr}$ giving rise to time scales of EEG [K113] and even longer time scales. Even the galactic MB could be involved as the fact that certain biorhythms are naturally expressed in terms of galactic day and year suggests. These would give rise to the analogs of EEG and time scales of human consciousness (say hour or day).

8.6.2 Can we smell and taste the value of \hbar_{eff}/\hbar ?

$\hbar_{eff}/\hbar = n$ brings in new degrees of freedom associated with the Galois group. If the proposed interpretation makes sense, one can ask whether evolution might have developed sensory perception of \hbar_{eff}/\hbar .

1. The same molecule can have large number of chemically more or less identical variants differing only by the values of n assignable to its atoms and with its MB. I learned long time ago from my chemist friend in sauna discussion that it has not been possible to produce artificially vanilla having the same taste as the natural vanilla. Maybe the explanation derives from these number theoretical degrees of freedom.

This leads to expect that biomolecules, cells and larger structures can have different distributions of n both in short and long scales. In particular, neurons could be cellular elite in this respect and even differences between individuals of the same species can be imagined and it might be that the life style could affect the distribution of n . This might have rather interesting implications concerning the taste of food. The chef could have a decisive role in determining the taste of food. Also the so called junk food could have very low value of n as a consequence of preparation process.

2. The higher the value of $\hbar_{eff}/\hbar = n$, the higher the complexity of extension of rationals, and the higher the value of maximal entanglement negentropy, and therefore the intelligence of the system. Dark atoms are possible and therefore dark variants of molecules. Also dark variants of nuclei are possible and the numbers for states of dark proton sequences turn out to correspond to those of DNA, RNA, tRNA, and amino-acids [L34]. Furthermore, the numbers of DNA codons coding for given amino-acid in vertebrate genetic code are predicted correctly. The proposal is that dark analogs of basic biomolecules have served as templates

for visible molecular biomatter: biochemistry would be dynamics of shadows. Dark matter would be master and biomolecules the slave.

3. If this picture is correct, one can characterize biomolecules and also larger systems by the spectrum of the values of n identified as dimension of extension and also by the value spectrum for the order $\text{ord}(G)$ of Galois group characterizing the algebraic complexity of the extensions. Best nutrients would have large average value of n and large $\text{ord}(G)$, which is maximal for $n = p$, p prime- p -adic physics again! Therefore it would very advantageous to sensorily perceive the value of n . Maybe odors and tastes give idea about the value of n . The better the odor or taste, the higher the value of n !

This would also explain why excretion products smell bad. It has low value of n since metabolism has removed from excretion produces the dark component as effectively as possible and therefore they are not good as nutrients except possibly for bacteria. Same applies to non-organic matter and therefore it cannot be used as nutrients.

Also in sexual reproduction it is advantageous to find the best possible partner and high average value of n is desirable. Pheromones giving rise to social odors are central here. Pheromones could carry information about the spectrum of n . They could thus carry not only information about - say - genome but also about number theoretic IQ.

4. One can also understand the emergence of immune systems. Dark atoms - number theoretical complexity - are cognitive currency and living systems are fighting for it. The dirty trick is to eat another living system and use its dark matter for own survival. We indeed eat other animals and plants instead of being happy with sun-light as some spiritual people claim to be. Even cells are autophagy "eating" those parts of cell, which are not functioning properly.

Immune system would have evolved to prevent dark atom thefts. Both micro- and macro-organisms (in particular in capitalism and market economy!) would do their best to steal negentropy and dark matter. Also viruses could steal dark atoms and thus energy and information from a more advanced system.

5. It is also possible to clone maximal entanglement with density matrix proportional to unit matrix. The conjecture is that number theoretic entanglement for which the p -adic variants of density matrix reduces to unit matrix but not necessarily the one, can be also cloned. Shared joy is doubled joy. This would be alternative but rather rarely used strategy of survival.

8.6.3 Adelic physics and cognition

It took more than 10 years to deduce hierarchy of dark matters as hierarchy of Planck constants from what I call adelic physics.

1. The notion of p -adic physics was introduced by colleagues already around 1990. In lack of any idea about the connection to reality it however remained purely formal exercises such as the construction of p -adic variants of quantum field theories.

At that time I however realized that p -adic thermodynamics for a system with super-conformal invariance and standard model symmetries predicted by TGD provides extremely elegant description of particle massivation and that the predictions are correct with one per cent accuracy if p -adic length scale hypothesis stating that primes near certain powers of two are physically favored [K78].

This forced the question about interpretation and about how to integrate real and various p -adic physics to a larger coherent whole

2. Adelic physics is indeed a fusion of real physics for matter and various p -adic physics for cognition, p prime. Various number fields are like pages of a book having common back consisting of rational numbers common to all of them.

Allowing extensions of rational numbers (by adding roots of N :th order polynomial) one obtain reals and induced extensions of p -adic number fields. Entire hierarchy of books defined by the extensions of rationals. This defines hierarchy of adelic physics identified as evolutionary hierarchy.

3. It became clear already in the beginning that $h_{eff}/h = n$ naturally corresponds to the number of sheets of space-time surface representable as a covering space. Galois group of extension act as its automorphisms respecting arithmetics.

Since cognitive representations correspond to intersections of real and p-adic space-time surfaces having points with coordinates in the extension of rationals as common points, Galois group has a natural action to this cognitive representation and gives rise to n -fold covering space. The identification of $h_{eff}/h = n$ as the dimension of extension dividing the order of Galois group is natural. Cognitive degrees of freedom are discrete degrees of freedom characterized by the Galois group of extensions.

$n > 0$ measures the complexity of extension and it is bound to increase in quantum jumps like the distance from the origin in random walk at half line. This implies evolution. The Universe becomes algebraically increasingly complex. This also means that its negentropy (negentropic entanglement) increase on the long run. Universe learns and this learning changes it.

Positive negentropy is made possible - as one might guess - by cognition that is p-adic number fields: for these one can indeed generalize Shannon entropy so that it gets negative values and has interpretation as negentropy [L58]. This implies that NMP - originally postulated as a separate principle - follows from adelic physics and holds true in statistical sense. We do not live in the best possible world since this form of principle allows us to do stupid things.

4. p-Adic differential equations have a very special feature that one can have non-constant functions with zero derivative. Integration constants are piecewise constant functions and differential equations are non-deterministic. This corresponds to the non-determinism of imagination.

If one has fixed the cognitive representation defined by points with coordinates in extension of rationals one can ask if it can be continued to a preferred extremals of action. In p-adic sectors pseudo-constants make this easy: one can speak of imagination realized as p-adic space-time surface. In real sector continuation need not be possible. In this case the imagination is not realizable.

For some extensions of rationals there can be very many realizable imaginations. System is not only imaginative but also able to realize its imaginations. These extensions are winners in the fight for number theoretic survival.

Extensions of rationals are characterized by so called ramified primes. The generic rational prime decomposes to a maximal number of primes of extension (order of the polynomial determining it). For ramified primes this number is not maximal. There are good reasons to identify them as preferred p-adic primes for the extension in question. The preferred p-adic primes near to powers of two or small prime could be ramified primes for extensions, which have survived [L54].

8.6.4 Comments to the vision of James Kohl about top-down and bottom-up causation, immune system, nutrients, and olfaction

With these prerequisites I am ready to comment the claims of X picked rather randomly from his FB pages. I am of course not professional biologists and do not know about the detailed definitions of various notions.

Comments to the vision about hierarchy of causations

James Kohl: The sun's biological energy from top-down causation in microbes to the most recent model of bottom-up gene activation and cell type differentiation in vertebrates.

TGD: Solar photons provide the energy kicking atoms to dark states with larger $h_{eff}/h = n$ and large size scale proportional to n^2 . Whether solar photons are dark or transform to dark photons in the biosphere such that frequency is reduced but $E = h_{eff}f$ is not affected, is still unclear. Solar photons would in any case be effectively anti-entropic as Schrödinger conjectured. The maximal entanglement negentropy increases with h_{eff}/h since new number theoretic degrees of freedom making possible cognition emerge.

In TGD inspired quantum biology MB is a new key player. MB is the boss and the causation begins from the level of dark MB and proceeds down to the level of biomatter. One possibility is that the control signals go through genomes, where the counterpart of bottom-up cascade is initiated.

Genomes could form a hierarchy in which the MBs of separate cells would fuse to larger MBs and these in turn to even larger ones [K56, ?]. One could even have genome or organ, organism, population, or even species. The coding would be as bio-rhythms defined by cyclotron frequencies, which in turn correspond to energies in the universal energy range of visible and UV bio-photons ($E = h_{gr}f$) inducing molecular transitions.

Sensory input would arrive from cell membranes to the MB. EEG and its fractal variants would mediate this input [K44, K98]. Cell membrane would be a generalized Josephson junction generating dark Josephson radiation allowing the communication of the sensory input. Frequency modulation would be the manner to code sensory data represented as nerve pulses to Josephson radiation [K96].

Comments to the vision of James Kohl about immune system

I already described the view about immune system as preventing theft of dark matter.

1. **James Kohl:** For comparison, successful reproduction links energy from supercoiled DNA to protection of all organized genomes from virus-driven energy theft and pathology.

TGD: Dark atoms are cognitive currency and living systems are fighting for it. The dirty trick is to eat another living system. Immune system would have evolved to prevent dark atom thefts. Both micro- and macro-organisms (in particular in capitalism and market economy!) would do their best to steal negentropy and algebraic complexity - that is dark matter. Viruses could steal dark atoms and thus energy and information from more advanced system. Supercoiled DNA mentioned by James Kohl as system preventing viral energy theft could provide new dark atoms to compensate the stolen ones or serve as an immune system.

2. **James Kohl:** Theorists seem willing to continue to ignore all facts about UV-light induced DNA repair that were presented in the poster that linked femtosecond blasts of UV light to all biophysically constrained energy-dependent RNA-mediated changes in protein folding chemistry and to all differentiated morphological phenotypes and all differentiated behavioral phenotypes.

TGD: This suggests a new mechanism of metabolism or transfer of metabolic energy/increase of $h_{eff}/h = n$. In TGD dark photons with large value of $h_{eff}/h = n$ and low frequency but energy $E = h_{eff}f$ in visible (the original motivation for h_{eff} hypothesis) and UV range provide a mechanism of communications and also of metabolism having two variants based on positive and negative energy photons.

Positive energy photons would allow only passive reception of metabolic energy. Negative energy photons would make possible active gain of metabolic energy (remote metabolism): the system needing metabolic energy would send *negative* energy dark photons to a system able to receive them and thus provide the metabolic energy (quantum credit card).

Negative energy photons are analogs of phase conjugate light rays known to dissipate in “wrong” time direction). This is possible in ZEO, which is the basis of TGD inspired theory quantum measurement theory implying in turn theory of consciousness. Fantappie [J92] proposed long time ago that time direction in living matter can vary and introduced the notion of syntropy as time reversed entropy.

Dark photons travelling along flux tubes of a network of magnetic flux tubes would effectively replace sunlight and also the analog of photosynthesis could occur by using “artificial sunlight” rather than nutrient molecules.

3. **James Kohl:** Nothing suggests gene expression evolved to depend on any ATP-consuming factor. Gene expression is energy-dependent. It cannot evolve itself to be energy-dependent and that fact is exemplified in the context of my model of virus-driven energy theft and genomic entropy.

TGD: DNA repair mechanism involving UV light - recall that biophotons are in visible and UV - could kick atoms with reduced $h_{eff}/h = n$ back to states with large value of n - healing. Same applies to energy-dependent RNA-mediated changes in protein folding chemistry, etc...

TGD inspired comments about nutrients and pheromones

For a background reader can read the article “Human pheromones and food odors: epigenetic influences on the socioaffective nature of evolved behaviors” by Kohl (see <http://tinyurl.com/zammzfe>), which represents a lot of facts serving as constraints on TGD based view about odors and tastes as adelic qualia.

Pheromones are social odors: Kohl’s article “Nutrient-dependent/pheromone-controlled adaptive evolution: a model” (see <http://tinyurl.com/zb7c42y>) is about this aspect. The basic message is that nutritional odors and social odors control the behavior via hormones.

The TGD proposal is that these odors give information about the distribution of $h_{eff}/h = n$ distribution of nutrient and another individual and the value of n telling about number theoretic evolutionary level, could be the main factor: the larger the value of n , the more attractive the odor. The article “Honey bees as a model for understanding mechanisms of life history transitions” gives a nice example about how epigenetics determined by the nutrition determines the cast system of beehive.

1. **James Kohl:** This atoms-to-ecosystems model of ecological adaptations links nutrient-dependent epigenetic effects on base pairs and amino acid substitutions to pheromone-controlled changes in the microRNA / messenger RNA balance and chromosomal rearrangements.

TGD: The distribution of values of $h_{eff}/h = n$ for the dark atoms (at least hydrogens) in DNA, amino-acids, and biomolecules in general tells the evolutionary level of DNA, measured also as complexity. It is affected by nutrients if metabolism creates a dark atom in phosphate with same value of $h_{eff}/h = n$ as in nutrient. Complexity of nutrient is transferred to the organism: both its morphology and behaviors (ZEO implies that behaviors correspond to 4-D morphologies for space-time surfaces!). The complexity of the organism’s biochemistry correlates with that of its nutrients.

Two DNAs can be identical chemically but at very different evolutionary level. This is seen in epigenesis and different forms of gene expression and also as large fraction of introns possibly involved with quantum computational activities made possible by braiding of magnetic flux tubes connecting DNA and lipid layers and/or microtubules and axonal lipid layers [K3].

Nutrients contain dark (not necessarily only hydrogen) atoms characterized by $h_{eff}/h = n$. The higher the average value of n , the more negentropic the nutrient is. We would smell the average value of n ! The higher the value of n , the better the smell. Metabolic process picks dark atoms from the nutrient and the end product has a low negentropy: it smells bad. Not a good idea to eat it. This is why olfactory system is so important. This also explains why we do not eat non-organic matter.

Quite generally, various disorders and diseases mean reduction of the average value of n in some parts of organism inducing also the reduction of the complexity of DNA, and therefore that of gene expression, and makes the system vulnerable to mutations and attacks of micro-organisms. The generic healing mechanism would be simple: increase the value of n .

2. **James Kohl:** The *nutrient-dependent pheromone-controlled changes* are required for the thermodynamic regulation of intracellular signaling, which enables biophysically constrained nutrient-dependent protein folding; experience-dependent receptor-mediated behaviors, and organism-level thermoregulation in ever-changing ecological niches and social niches.

TGD: If the metabolic effect of nutrient depends on $h_{eff}/h = n$, also effects on protein folding are expected. The detailed mechanism could rely on remote metabolism based on dark photon - either active or passive - dark photons would have h_{eff}/h assignable to the nutrient and be involved with protein folding and DNA activities and large n would be optimal: you are what you eat!

Vegetarians believe that vegetables are better nutrients than meat: could plant molecules have higher average intelligence quotient $h_{eff}/h = n$ than meat? How much the preparation of the food can affect the value of n . Could here be the secret of master chef? Could microwave ovens reduce it?

3. **James Kohl:** Nutrient-dependent pheromone-controlled ecological, social, neurogenic and socio-cognitive niche construction are manifested in increasing organismal complexity in species from microbes to man. Species diversity is a biologically-based nutrient-dependent morphological fact and species-specific pheromones control the physiology of reproduction.

The reciprocal relationships of species-typical nutrient-dependent morphological and behavioral diversity are enabled by pheromone-controlled reproduction. Ecological variations and biophysically constrained natural selection of nutrients cause the behaviors that enable ecological adaptations.

Species diversity is ecologically validated proof-of-concept. Ideas from population genetics, which exclude ecological factors, are integrated with an experimental evidence-based approach that establishes what is currently known. This is known: olfactory/ pheromonal input links food odors and social odors from the epigenetic landscape to the physical landscape of DNA in the organized genomes of species from microbes to man during their development.

TGD: This is what is expected. Good nutrients increase the complexity of organisms and its behavioral repertoire. Pheromones tell among other things about genotype. They could also tell about the distribution of n : about complexity, about the level of molecular intelligence. This would give connection with nutrition and complexity of of pheromones and in turn link with success in reproduction.

Chapter 9

Macroscopic Quantum Coherence and Quantum Metabolism as Different Sides of the Same Coin: Part II

9.1 Introduction

This chapter was originally a part of the chapter devoted to TGD inspired ideas about metabolism. It however turned out a good idea to divide the chapter to two parts. The basic topics of this chapter are TGD inspired views about brain metabolism and molecular machines in many-sheeted space-time.

9.1.1 Quantum View About Energy Economy In Brain

The application of these ideas results in a rather detailed model for the energy economy of brain (I will use the word metabolism in the sequel in the meaning energy economy). As a byproduct more detailed models for the generation of projector MEs to the magnetic sensory canvases and for the realization of motor control from the sensory canvas emerge.

Magnetic bodies as key participants of metabolic activities?

As already explained, dark matter hierarchy forces to consider the possibility that magnetic bodies are majors users of metabolic energy, and that magnetic bodies suck metabolic energy from the biological body as they realize intentional actions using time mirror mechanism by sending negative energy dark photons at cyclotron frequencies to the biological body.

This might relate to the paradoxical findings that much more oxygen rushes to coherently firing neuron groups than needed to satisfy the metabolic needs but that neurons actually utilize only a small fraction of this oxygen. Could it be that blood provides the metabolic energy and magnetic bodies are the users the metabolic energy rather than neurons? Could glial cells communicate the EEG signal to the magnetic body. Could the usual $\text{ADP} \rightarrow \text{ATP}$ transformation provide the metabolic energy in this case?

Or is time mirror mechanism involved meaning that magnetic body sends negative energy signals to the biological body. Also in this case it could be that positive metabolic energy is generated by $\text{ADP} \rightarrow \text{ATP}$ transformation provide the metabolic energy.

The hierarchy of Planck constants allows to understand the unexpected use of metabolic energy: it could go to generation of EEG. Dark photons with ELF frequencies have energies in visible and UV range if their decay products are biophotons as assumed in the model of biophotons constructure years later than this chapter was written.

“Holy trinity” of red blood cells, astrocytes, and neurons

The model for the quantum metabolism of brain is based on the trinity of red blood cells, astrocytes, and neurons.

1. The hypothesis is that red blood cell colony represents the state of the internal milieu (“how it feels”) in corresponding magnetic body. Neurons in turn generate the representations corresponding to the sensory input from the external world or body as seen by an outsider (“how it looks”). Both red blood cells and pyramidal neurons are magnetic and the ability to act as compass needles makes them excellent candidates for magneto-receptors. This would make them able to represent information about the orientation of body with respect to the reference frame defined by the direction of the gravitational and magnetic fields of Earth. Even honeybees are known to utilize magneto-receptors for navigation purposes.
2. Blood-brain barrier could be seen as a counterpart for the body-environment boundary. One of the almost-predictions is that during sleep a delegation of the responsibilities from the cortical level to the lower levels occurs and these lower level structures, including red blood cells and probably also ordinary cells, generate sensory and motor representations. The cellular representations should be accompanied by a radio frequency counterpart of EEG corresponding to lower levels of dark matter hierarchy. This kind of radio static has been indeed identified as I learned when building a model for taos hum [K98].
3. Ca^{++} waves form a hierarchy with frequencies for their generation varying in enormous range. The interpretation as analogs of nerve pulse communications at $k \geq 3$ of dark matter hierarchy is attractive. Astrocytes serving as metabolic resources take a key role in quantum control based on the control of metabolic resources. Magnetic body would communicate its desires to the astrocyte syntica via synchronously firing neuron groups using Ca^{++} waves propagating along syntica. The frequency for the generation of Ca^{++} waves is few/minute, which suggests that they relate to quantum motor control at $k_d = 54$ level of dark hierarchy for two minute period. Note that the hypothesis is $h_{eff} = nh$, where n is product of distinct Fermat primes and power 2^{k_d} . This and the fact that also short term memory corresponds to in this range encourages the interpretation that natural language and internal speech corresponds to signals communicated from magnetic body to syntica as Ca^{++} waves.
4. Sound waves are known to couple directly to Ca^{++} waves. Astrocyte syntica have endfeet to blood vessels. Blood vessels can mediate endogenous sound waves to syntica, where they give rise to Ca^{++} waves propagating along gap junction connected astrocyte structures (syntica). There are reasons to believe that physiophonic sounds and taos hum relate very closely to this kind of endogenous sounds. Dark matter hierarchy suggests that there is an entire hierarchy of “internal speeches” effectively giving rise to a Fourier analysis of the control signals from the magnetic body and transformed in turn to mechanical, chemical, and electrical control signals representing concretely the Fourier components.
5. The general vision about realization of intentions are using time mirror mechanism and remote metabolism provides also concrete ideas about how the coherent locomotion is realized. The basic problem is to understand how coherent momentum generation in macroscopic length scales is possible and the proposed solution to this problem is based on the notion of many-sheeted space-time. Interestingly, the same mechanism explains a bundle of anomalies related to the over-unity energy production and strange facts about electrolysis of water discovered already a century ago by the nobelist Irving Langmuir. Therefore, somewhat surprisingly, a direct connection with the new energy technologies and quantum biology emerges.

9.1.2 Molecular Machines In Many-Sheeted Space-Time

Molecular motors have become the hot topics of biology. The so called Brownian motors are the dominating theoretical paradigm but there are some empirical findings challenging the concept. TGD suggests an alternative approach based on the notion of quantum motor. The basic idea is that all moving parts of the quantum motor move on the non-atomic space-time sheets so that momentum dissipation is minimal. It turns out that this picture might work but that TGD allows

both quantum and classical modes for the molecular motors and it is quite possible that both modes are present. The phase transitions changing Planck constant and inducing shortening or lengthening of the magnetic flux tubes connecting molecules could be the basic mechanism behind various motor activities.

The model allows a new view about the real function of ATP leading to precisely correct quantitative predictions.

1. ATP molecules are certainly in a key role in the energetics of life but one might argue that the notion of high energy phosphate bond is not theoretically sound. In TGD framework the dropping of protons from atomic space-time sheets to super-conducting space-time sheets liberating zero point kinetic energy .49 eV is the fundamental mechanism generating usable energy. This leads to a new view about the role of ATP forcing to give up the notion of the high energy phosphate bond.
2. In quantum mode molecular motor receives its energy as a single photon with energy .49 eV emitted when a proton drops to the super-conducting space-time sheet. In classical mode the dropping of the proton to high n cyclotron state generates a cascade of ELF photons with frequencies equal to multiples of the cyclotron frequency of proton giving rise to a radiation pressure forcing the motion of the motor molecule.
3. The model explains the homeopathic $f_h/f_{ELF} = 2 \times 10^{11}$ scaling law: the ratio in question could correspond to the ratio of the zero point kinetic energy and cyclotron energy of ion. Quantum model for molecular motors predicts correctly the order of magnitude for the velocities of these motors and the general time scale of molecular motors is predicted correctly as the time scale defined by the proton cyclotron frequency $f_c \simeq 300$ Hz. The phase transition $\hbar_0 \rightarrow 2 \times 10^{11} \hbar_0$ could transform photons with cyclotron frequency and extremely small frequency to photons possessing zero point kinetic energy which is above thermal threshold.
4. The model allows to understand cell membrane as a barrier preventing the leakage of proton Cooper pairs from $k = 139$ super-conducting space-time sheets to the magnetic flux tubes of Earth's magnetic field and a new view about nerve pulse and EEG results. Besides proton also electron and heavier ions can in principle serve as providers of energy and the latter could make possible more refined bio-energetics.

What looks really mysterious in the conceptual framework of the standard bio-chemistry, where proteins are nothing but inanimate molecules, is that nano-motors are able to co-operate and behave like an advanced society rather than a collection of dead and autistic robots colliding continually with each other. Dark matter hierarchy makes it easier to understand what is involved. Dark matter hierarchy leads to the notion super-genome and hyper-genome [K44] : these generalizations could make sense also in the case of nucleus and cell. Super-genome integrates the genomes of individual nuclei to sequences analogous to lines of written text: the page of the book corresponds to a magnetic flux sheet traversing through DNA strands of several nuclei. Super-genome would make possible to interpret organs and societies of nano-motors as motor instruments of magnetic bodies.

I have been forced to learn a lot of new things about the metabolism of brain and molecular motors and do not pretend of being more than a novice in the field. Despite this I dare hope that the power of the general vision compensates the lag of professional rigor as far as biological knowledge is considered.

I have included to the end of the chapter also other miscellaneous topics such as an old proposal for the possible role of four-wave interactions in the construction of conscious holograms.

The appendix of the book gives a summary about basic concepts of TGD with illustrations. Pdf representation of same files serving as a kind of glossary can be found at <http://tgdtheory.fi/tgdglossary.pdf> [L21].

9.2 A General Model For Metabolism

The general strategy in attempts to understand metabolism is based on the assumption that a very large class of anomalous phenomena rely on same basic mechanism. This includes life

as a phenomenon, water memory and homeopathy, free energy phenomena involving over-unity phenomena related to the dissociation of water, lightning and ball lightning, anomalous effects associated with rotating magnetic systems, phenomena related to UFOs (light balls), even remote mental interactions. One must have a unified explanation for all these phenomena based on a real theory.

Plasmoid as primitive life form would be the underlying connecting thread between these phenomena so that all the listed phenomena would involve life and prebiotic (or possibly postbiotic!) life. This gives very strong constraints on the model. Plasmoid should consist of the analogs of linear biomolecules, it should metabolize and communicate, in TGD Universe it should have magnetic body, and even genetic code might be realized. In particular, the simplified analog of biological metabolism would be at work. In living matter photosynthesis relies on the splitting of water whereas cell respiration relies on the reversal of this process producing carbon di-oxide and water. Something very similar should happen in free energy systems involving electrolysis, and the fact that water splitting occurs also in several free energy phenomena suggests that these processes are analogous to photosynthesis and store energy to “molecules” analogous to various linear biomolecules, in particular sugars. Even the counterpart of ADP-ATP process might be realized.

TGD suggests a very general model for the metabolism of pre-biotic systems (or post-biotic ones: the identification depends on what general vision about evolution is adopted) identified as plasmoids consisting of cyclic linear structures formed by exotic water molecules. For a dark water molecule one proton would be dark and dark protons of the neighboring exotic water molecules would bind to form a linear structure identifiable as dark nucleus: this picture is a direct generalization of nuclear string model [K47, K45, L3]. These linear structures would define the analogs of linear biomolecules. This metabolism would be more fundamental than ordinary biochemical metabolism and form a yet unknown part of the latter. One cannot exclude the possibility that also other than water molecules contain dark protons: the signature would be the presence of apparently non-allowed covalent bonds due to the fact the dark proton is not visible. In the following I will discuss the basic principles involved.

The old view about the metabolic energy quanta as energies liberated as particle “drops” to a larger space-time sheet is modified. Metabolic energy quanta are liberated when the space-time sheet at which the particles reside expands in a phase transition increasing its p-adic prime and reducing the value of Planck constant correspondingly so that the net result is that the size of the space-time sheet remains the same. This condition implies a close relationship between p-adic and dark matter hierarchies. This process is automatically coherent since all particles suffer the change simultaneously. It applies also to a situation in which particles are in magnetic field: in this case the scale of cyclotron energies changes since the strength of the magnetic field is scaled down to guarantee the conservation of magnetic flux. This transition is not cyclotron transition but liberates essentially the same energy as coherent cyclotron transition so that magnetic fields (their “motor actions”) become essential players also in metabolic activities.

9.2.1 Three Possible Models For Liberation Of Metabolic Energy

One can imagine three different models for the liberation of metabolic energy.

1. The simplest TGD based model is as a phase transition increasing the value of p-adic prime p assignable to the space-time sheet at which particle is topologically condensed:
 - (a) Particle drops to a larger space-time sheet with larger p-adic prime p_1 with $p_1/p \simeq 2^k$. The problem is that different particles need not drop simultaneously so that coherent liberation of energy is not automatic consequence of the assumption.
 - (b) The space-time sheet itself suffers a phase transition increasing its p-adic length scale. In absence of interactions (particles in box) the energies are scaled down by factor 2^{-k} and the difference is liberated as usable energy. Coherent liberation of energy is achieved automatically. If the particle inside the space-time sheet is free in good approximation a model as particle in box applies, and if the expansion of the space-time sheet takes place adiabatically, the quantum numbers characterizing the state of

the particle do not change in the transition. As a consequence, the energy $E_{\{n_i\}} = k \sum_i n_i^2 \hbar^2 / 2mL_p^2$ is reduced as $L_p \propto \sqrt{p}$ increases to L_{p_1} , where $p_1/p \simeq 2^k$ holds true. The difference of vacuum energies is liberated as usable energy in coherent manner: this is of special significance in living systems. This has led to the identification of p-adic length scales that would correspond to fundamental metabolic quantum with value about .5 eV. Entire hierarchy of metabolic quanta is predicted.

2. The space-time sheet could also carry magnetic energy and particles are expected to be in cyclotron states and perhaps form a cyclotron Bose-Einstein condensate. In this case the phase transition reduces the value of B but preserves the magnetic flux so that $B \rightarrow B/2^k$, $p_1/p \simeq 2^k$, takes place. This scales down the energies of cyclotron states by the same scaling factor 2^{-k} as in the case of free particle. The liberated energy is in good approximation just the cyclotron energy for large enough values of k . Coherence is achieved automatically. The value of the fundamental metabolic energy quantum and the value of endogenous magnetic field of about $B_{end} = .2$ Gauss deduced from the experiments of Blackman and others [J47] fix the value of \hbar_{eff} . It would be proportional to particle mass number A .
3. The earlier model for the liberation of cyclotron energy was based on the assumption that the value of B is not changed but that the value of magnetic quantum number n changed. If n is reduced one achieves liberation of energy. Coherence of the transition might produce problems now. Both models can explain the observations of Blackman and others concerning the effects of ELF radiation on vertebrate brain since the spectrum of photons energies inducing effects correspond to cyclotron energies for the latter option and in excellent approximation to it for the previous model. The mechanism is however quite different.

This phase transition for the larger space-time sheet can take place in two steps.

1. First a phase transition increasing \hbar_{eff} of the background space-time sheet by $n = 2^k$ occurs. This leaves ZPKE invariant but scales up the size of the space-time sheet by $2^{k/2}$. The interpretation would be as “electric expansion” of Brown’s gas. No energy transfer takes place since both kinetic and magnetic energies are invariant under the scaling of \hbar . Note however than in the original situation the magnetic field can be very strong so that zooming up from microscopic scales can happen.
2. After this a phase transition reducing Planck constant back to \hbar but increasing p-adic length scale by 2^k occurs. The size scale of the background space-time sheet is not affected but the zero point kinetic energy is reduced by factor 2^{-k} and liberated as usable energy. This phase transition would take place for the dark component of Brown’s gas in the melting of the metal and other similar phenomena. Also the liberation of metabolic energy in living matter could correspond to this phase transition.

This model for electric expansion, implosion, and energy liberation assumes nothing about the particles involved since dark particle means ordinary particle topologically condensed on dark space-time sheet and having wave function de-localized in the n-sheeted structure. For instance, water can be dark in this sense. One could indeed consider the possibility that the vapour phase identified as charged water cluster is just water containing positive ions H_+^3 or protons and electrons and that phase transition to large \hbar phase expands the space-time sheet at which water is topologically condensed at evaporates the water. Ordinary liquid to gas transition could proceed in the same manner and involve liberation of ZPKE at the second step of the process. In the general case the binding energy involved with the formation of the denser phase could compensate for the energy gain in the increase of the p-adic prime so that the melting would require energy feed.

9.2.2 Model For The Building Bricks Of Plasmoids

I have already earlier discussed a model for dark proton sequences as primitive life forms. The observation discussed by Moray B. King inspired a more detailed formulation of the model of plasmoids identified as primitive life forms in TGD framework.

1. The key observation was that the model for dark nuclei [L3, K58], in particular dark proton, predicts counterparts of DNA, RNA, tRNA, and amino-acids and also vertebrate genetic code follows naturally. This together with nuclear string model led to the vision that life appears already at the level of dark variants of nuclei. The observed anomalous $H_{1.5}O$ stoichiometry of water in atto-second scale supports the view that dark protons appear in ordinary water.
2. This model was first introduced to explain water memory and homeopathy. The basic idea was that the process creating homeopathic remedy induces the analog of molecular evolution for the dark proton sequences, which in turn provide representations for the molecules appearing in environment. These representations would be fundamental also for the functioning of immune system of living matter. The dark life could provide R&D laboratory for living matter allowing to test say various gene candidates and transcribe them to ordinary biological DNAs if they are successful in the virtual model world. Evolution would not be random but directed just as evolution of technologies.
3. The latest step in the process [K26] was the proposal that cell membranes involve dark proton sequences providing a representation of dark DNA and connected by magnetic flux tubes to the units of DNA in genome. These two DNA representations would be identical. Quite generally, dark and ordinary biomolecules might be connected by magnetic flux tubes.

This picture does not yet provide model for the metabolism of the building bricks of plasmoids. Something very much analogous to the splitting of sugars to carbon di-oxide and water is however expected. Since carbon is not present now, this leaves only the option that the linear dark structures are nothing but exotic form of water for which the proton of one hydrogen atom of each water molecule is dark. These dark protons would combine by strong interactions to a nuclear string and O-H groups would be attached to them. The cyclic analog of DNA, RNA, or amino-acid realizing genetic code would be the outcome. The stoichiometry $H_{1.5}O$ observed in atto-second time scale would be achieved in average sense if the portions of exotic and dark water are same. The prediction is that dark water is heavier than ordinary water: the molecular weight would correspond to average length of the dark water cycle. This is consistent with the observations about Brown's gas.

Plasmoid should also possess a magnetic body. This requires a currents rotating along the cyclic structures. The obvious identification of the current is as dark supra currents assignable to dark protons so that the building bricks of plasmoid would be analogous to super-conducting rings.

9.2.3 Model For The Metabolism Of Plasmoids

The proposed dark analogs of basic biomolecules would be created through the analog of photosynthesis involving the splitting of water to $H + OH$ followed by $H \rightarrow H_{dark}$ and by recombination to a sequence of dark water molecules. The process would be analogous to translation of mRNA to amino-acids and could proceed by an analogous mechanism. The process would be spontaneous since the energy of cyclotron states would not change in $h \rightarrow h_{eff} = 2^k \times h$.

Metabolic energy would be liberated in the decay of the exotic water back to water with $h_{eff} = h$ and p-adic prime scaled by about 2^k . This process is completely analogous to the splitting of various linear biomolecules in metabolism in order to obtain metabolic energy. This process would explain the ability of cool Brown's gas to melt metal for instance. When fossil fuels are used, the outcome is carbon di-oxide and water. Now only water is obtained so that this form of free energy might not contribute to the warming of environment.

The process differs from ZPE in that it does not provide any endless source of energy. Since water is in practice an unlimited natural resource, this should not be a problem. A closed cycle at the level of visible matter is obtained only if the reverse phase transition transforming the water with $h_{eff} = h$ and p-adic prime $p_1 \simeq 2^{k/2}p$ to that with $h_{eff} = 2^k \times h$ and p-adic prime p takes place spontaneously.

The irradiation with carrier frequency f_h and modulation frequency f_l such that one has $f_l/f_h = 2^k$ is one possibility which I have proposed. Dark solar radiation at magnetic flux tubes with magnetic field $B_{end} = .2$ Gauss (guess from the experiments of Blackman [J47] ; also many other values can be considered) could provide automatically the needed pulsed radiation inducing

the phase transition. The most optimistic option is that this transition occurs even in the case of closed system in which water circulates.

Before attempting to identify reasonable candidates for f_l and f_h it is useful to consider estimates for $h_{eff}/h = 2^k$. Note that this assumption might be too strong: the vision about evolution as emergence of number theoretical complexity suggests that so called Fermat integers defining polygons, which are constructible using ruler and compass, define favored values of $h_{eff}/h = n$ [K47]. These integers are expressible as products of different Fermat primes $F_n = 2^{2^k} + 1$ and power of 2. The known Fermat primes correspond to $k = 0, 1, 2, 3, 4$ and are 3, 5, 17, 257, 65537. Only the two lowest ones differ significantly from power of two. This raises the question whether also the scale hierarchies $\sqrt{3}L(k)$, $\sqrt{5}L(k)$, and $\sqrt{15}L(k)$ are important besides p-adic length scale hierarchy $L(k) = 2^{k/2}R_{CP_2}$. They could be associated with the algebraic extensions of p-adic numbers involving $\sqrt{3}$ and $\sqrt{5}$.

1. The condition that cold nuclear fusion is possible via the TGD based mechanism requires dark variant of weak interactions corresponds to scaled up p-adic length scale of order atomic size. The condition that weak bosons are effectively massless in atomic length scale gives one estimate for h_{eff}/h . The condition that weak scale characterized by M_{89} is increased to that characterized by M_{127} gives $h_{eff}/h = 2^{48} \simeq 2.8 \times 10^{14}$.

2. Second estimate for h_{eff}/h follows from the condition that cyclotron energy for given charged particle is of the order of metabolic energy quantum. For proton $B_{end} = .2$ Gauss gives $f_c = 300$ Hz. The energy is about .5 eV for $h_{eff}/h = 1.37 \times 10^{14}$ rather near to $h_{eff}/h = 2^{47}$ which is by a factor of 1/2 smaller than the previous estimate. It is however clear that the estimates are internally consistent: skeptic would see this as a pure accident and some-one taking anthropic principle seriously as an outcome of evolution in very general sense. Note that for electron the metabolic energy quantum would be about 938 eV suggesting that keV energy scale assignable to the dark weak interactions has its own metabolic energy quantum.

For ion of mass number A and ionization z the value producing the same value of metabolic quantum is $A/z \times 1.37 \times 10^{14}$. An alternative assumption is a hierarchy of metabolic quanta coming as z/A multiples of the fundamental metabolic energy quantum for a fixed value of h_{eff}/h . The condition that the metabolic energy quantum is above thermal energy of photon at physiological temperature for which peak wavelength for blackbody radiation corresponds to energy of .13 eV. This gives $A/z \leq .5/.13 = 3.84$. The estimate is too stringent since Ca^{++} with $A/z = 20$ should allow metabolic energy quantum above the thermal energy. This suggests that h_{eff}/h characterizes given ion and that its multiples coming as power of two are allowed.

3. For $h_{eff}/h = n = 2^{k_{dark}}$ with $k_{dark} \in \{47, 48\}$ dark electron would have p-adic length scale $L(k)$, $k = 127 + d_{dark} \in \{174, 175\}$. This corresponds to a Compton length $l_c \in \{28, 40\} \mu m$. That this corresponds to the size scale of cell gives additional support for the vision. Note also that for electron the size scale of CD identified as secondary p-adic time scale associated with $M_{127} = 2^{127} - 1$ corresponds to .1 seconds, which defines a fundamental biorhythm. Proton Compton length would be scaled to the range [15, 21] nm (10 nm defines the thickness of the cell membrane) and light current quarks with energy of 5-20 MeV to the size scale of cell nucleus.

A reasonable guess is that the candidates for f_h and f_l should satisfy the condition $f_h/f_l = 2^k$, $k = 47$ or $k = 48$. f_h can be deduced from the estimate for h_{eff} .

1. Schumann frequency 7.8 Hz is the first candidate for the modulating frequency. This would give UV frequency $f_h \simeq 1.1 \times 10^{15}$ Hz corresponding to energy of 9.7 eV for $k = 47$, which corresponds to the energy scale for covalent bonds. The energy scale of hydrogen atom is 13.6 eV.
2. For the cyclotron frequency of DNA (which depends only weakly on the length of the DNA sequence due to the constant charge density per unit length) of about 1 Hz (the frequency of heart beat) one would obtain $f_h = 1.4 \times 10^{14}$ Hz for $k = 47$, which corresponds to energy of 1.4 eV and is just below the visible range starting around 1.65 eV. The scaling of this energy

by $\sqrt{3}/2$, $\sqrt{5}/4$, and $\sqrt{15}/4$ By multiplying the For $k = 48$ the energy would be to 3.3 eV, which is quite near to the UV end 3.36 eV of visible portion of spectrum. Again one can ask whether just accidents are in question.

Allowing the generalization of the p-adic length scale hypothesis one obtains 7 photon energies in the visible range corresponding to the scalings of 1.4 eV by $[\sqrt{3}/2, \sqrt{5}/4, \sqrt{5}/2, \sqrt{15}/4, \sqrt{3}, 2, \sqrt{15}/8, \sqrt{5}]$ giving $E/eV = [1.71, 1.57, 2.21, 1.91, 2.42, 2.71, 2.80, 3.13]$. Note that 2 eV corresponds to red light and metabolic energy quantum of 50 eV to $k = 51$. An interesting question is whether these special frequencies relate to the peak wave lengths for color vision.

A macroscopic variant of photosynthesis using the possibly existing dark photons at the flux tubes of $B_{end} = .2$ Gauss [J47] can be imagined. The flux tubes of B_{end} could correspond to those of B_E with nominal value .5 Gauss if a weakening of the field value takes place inside living matter. Note that in case of $h_{eff}/h \sim 10^{14}$ this field value would correspond to about 10^{10} Tesla for the ordinary value of \hbar (a field strengths assignable to supernovas!) and assignable to electron Compton scale.

The sequences of these two phase transitions involved with dark metabolism would be very much analogous to .-ATP-ADP-ATP-... “Karma’s cycle”. There is also a strong analogy with breathing and even sleep-wake-up cycle and longer bio-rhythms. p-Adic fractality forces to ask whether all these rhythms involve the same dark metabolic cycle but in different scales. Increase of h_{eff} indeed corresponds to an increase of “IQ” in TGD inspired theory of consciousness and its reduction to its lowering. This could quite concretely correspond the experience of becoming tired. There is also a close analogy with the state function reduction sequence in ZEO. State function reductions occur alternatively at the opposite boundaries of causal diamond (CD) of given scale and I have proposed an interpretation in terms of generalized sleep-awake cycles.

9.2.4 Does Dark Biology Represent Pre- Or Post-Biotic Evolution?

The discovery of dark proton realization of genetic codons [L3, K58] was an accident and I am still puzzled about whether the vertebrate genetic code can really emerge from dark nuclear physics or is it only a curiosity or self deception. The first interpretation for the dark code is as a code associated with prebiotic evolution [K49, K50]. This is suggested by the enormous simplicity for the analogs of counterparts of linear biomolecules, and the fact that the utilization of metabolic energy means that these “molecules” decay to ordinary water. In this view life would have migrated from dark space-time sheets to visible space-time sheets. This higher level life would be gradually migrating to lower levels in the hierarchy and taking visible matter to its control and that biological evolution represents a step in this process.

There are however some objections against this view. The dark code corresponds to vertebrate code, which can be seen as an outcome of along genetic evolution. There are also other codes, which are less perfect (thes are discussed in [K35] representing a number theoretic approach to genetic code). For instance, the meaning of the codeword is context dependent for some codons and Peter Gariaev has proposed that this context dependence is a more general phenomenon. One would expect that prebiotic code is much simpler than genetic code and I have considered a model for how genetic code might have emerged from more primitive codes with 4 and 16 code words as a “product code” [K35, ?].

These objections inspire the question whether life could migrate from lower to higher scales. The dark genetic code would in this framework correspond to the emergence of a new level in evolution - perhaps identifiable as cultural evolution. This would explain why dark variant of the genetic code corresponds to vertebrate code. One could also solve Fermi paradox [K139] due to the fact that no signs of intelligent life have been observed in cosmos and probabilistic estimate suggests that cosmos is full of life. The answer could be very simple: in some stage the civilization transforms to dark matter invisible to us! The civilizations are there but living on magnetic flux quanta and probably communicate with us telepathically. The higher evolutionary level would also conform with the fact that the spatial and temporal scales of consciousness are much longer than for the consciousness assignable to visible manner. This could allow also to understand also the mystery of crop circles. To my opinion many of them are genuine, and the interpretation as some kind of cognitive representations analogous to those realized in brain is highly suggestive.

Certainly these representations would represent mental images of conscious entities, which are at higher evolutionary level than us [K41, K40].

Many great leaps in evolution have occurred via crisis periods involving extinction. Could it be that gradual transition to dark matter based life could be begin as a response to the recent crises of human kind? The gradual transition of life to the dark matter level would indeed solve the energy problem by coupling us to the energy sources assignable to the dark matter hierarchy at various magnetic bodies. It would also solve the problem caused by the climate warming if it is indeed is due to the liberation of CO₂ as fossil fuels are used. The dark matter “molecules” as analogs of biomolecules and hydrocarbons would produce only water when used.

What has been bothering me somewhat are the messianic elements of free energy movement: something totally new is believed to be emerging even at the level of consciousness and ethics and moral rules. Skeptic scientist finds it difficult to accept the idea that new form of energy could have so wide implications: the fundamental problems of the society relate to ethics and moral. On the other hand, if one interprets free energy phenomena as manifestations of post-biotic life forms realizing genetic code at the level of dark matter, it becomes possible to defend the messianic view about free energy. The transition to dark matter dominated world would mean also leap in the level of consciousness.

The belief in ZEP has also some features that worry me. I believe that there is some great intuition behind this view but to me its realisation in terms of ZEP is wrong thing to do: the existing mathematical physics simply fails to provide the needed language and concepts. My own proposal is zero energy ontology (ZEO) in which physical states are replaced with physical events and continual re-creation becomes possible without giving up the symmetries and laws of physics.

I find it also alarming that some advocates of free energy also have a hostile attitude towards science. This is easy to understand as a reaction to the arrogant attitude of the academic world towards free energy and actually all visions challenging the basic dogmas of the standard science. Christianity emerged as the Roman Empire collapsed and something similar seems to happening now: at this time free energy movement might take the role of Christianity. It would be a pity if also now blind beliefs would replace rational thinking for almost two millenia.

9.2.5 Quantum Model For Metabolism

First it is good to list some basic facts about energy metabolism.

1. ADP → ATP meaning the addition of phosphate to ADP is believed to be the fundamental step of metabolism. The process occurs when protons flow through the ATP synthase, which can be regarded as a nano-motor with a rotating shaft. During single turn three ADPs are phosphorylated and 3 protons flow through the “turbine” of the nano-motor and give up their Coulombic and chemical energy parameterized in terms of chemical potential difference. There is clearly a strong analogy with power plant. High energy phosphate bond is believed to receive the metabolic energy transferred from the flow of protons through the mitochondrial membrane.
2. The nominal value of metabolic energy quantum about .5 eV. The Coulomb energy associated with the mitochondrial membrane is 50-80 meV and by almost order of magnitude too small. The large chemical potential difference is believed to explain the large metabolic energy gain. This requires that the process is regarded as purely thermodynamical. This is a questionable assumption even in standard physics context and does not conform with the TGD based idea that transmembrane proteins such as ATP synthase act as large h_{eff} Josephson junctions. The square root of thermodynamics forced by zero energy ontology suggests itself as a proper description of cell membrane as macroscopically quantum coherent system.
3. The notion of high energy phosphate bond is not well understood. The storage of energy dark cyclotron energy at the magnetic body of phosphate suggests itself as TGD based description.

How to understand the value of h_{eff} ?

The basis problem is to understand how h_{eff} depends on the parameters characterizing the situation at the magnetic flux tube connecting two systems. I have considered several mechanisms for the generation of large h_{eff} phase.

1. The model for h_{eff} in systems involving charge separation stimulated by AC current was based on the identification of Josephson frequency with the frequency of AC current: $f_J = E_J/h_{eff} = f_{AC}$ predicting $h_{eff}/h = E_J/hf_{AC}$ [K9].

The findings of Pollack and the difficulties to understand metabolic energy quantum of nominal value 5 eV in the simplest model for cell membrane as Josephson junction as Josephson energy for Cooper pair equal to $ZeV = 10 - 10.6$ mV inspired the assumption that cyclotron energies at flux tubes traversing cell membrane can be different at the two sides of the cell membrane [K44, K94]. This would lead to a generalization of the notion of Josephson junction associated with the transmembrane protein and generalizes $f_J = f_{AC}$ to $\Delta f_c + f_J = f_{AC}$ predicting $h_{eff}/h = E_J/(h(\Delta f_c - f_{AC}))$ so that h_{eff}/h would get arbitrarily large values near resonance $f_{AC} = f_c$. Note that correct sign requires $\Delta f_c - f_{AC} > 0$.

2. The conjecture $h_{eff} = h_{gr} = GMm/v_0$ could make sense at microscopic level for particle-Earth pair and would predict a universal spectrum of bio-photons if identified as resulting from the decays of dark cyclotron photons to bio-photons. The first guess for the parameter v_0 would be as a rotational velocity associated with the two systems such as Earth and electron rotating with it. In case of planetary orbits $v = v_0$ is not consistent with

$$\frac{v}{c} = \frac{\sqrt{\frac{v_0}{c}}}{4\pi n}$$

following from Bohr rules in $1/r$ potential (n denotes the principal quantum number).

3. $h_{eff} = h_{em} = Z_1 Z_2 e^2 / v_0$ hypothesis is a natural looking generalization in systems involve large charge separations, say the exclusion zones discovered by Pollack providing a model for prebiotic life forms. The philosophy would be that when the coupling strength between systems becomes so large that perturbation theory fails, the value of h_{eff} increases and makes perturbation theory in powers of $1/h_{eff}$ possible again. At space-time level this means emergence of non-determinism so that 3-surfaces at the future and past boundaries of causal diamond are connected by n -branched space-time surface for which branches fuse at the two ends. Dark matter would be Nature's manner to define what non-perturbative phases are. The strong hypothesis $h_{eff} = h_{em} = h_{gr}$ might make possible reconnection between em and gravimagnetic flux tubes and ATP synthase is here a candidate system.
4. Rotating magnetic systems with high negative charge are also good candidates for generating large h_{eff} at the magnetic flux tubes possibly contain dark proton sequences identifiable as dark nuclei. I have also proposed that a system subject to constant torque allowing description in terms of potential function which is multivalued as function of the angle coordinate ϕ leads rather naturally to generation of large h_{eff} [K63] when one requires internal consistency.

How metabolic energy is transferred?

The basic question concerns the mechanism of energy transfer from nutrients. It should be however emphasized that the transfer might not be the really important aspect. The transfer of negentropic entanglement from nutrient to the organism might be of equal importance.

1. Zero energy ontology (ZEO) suggests that magnetic bodies are carriers of the metabolic energy. What does this mean is not quite clear but cyclotron energies or ions or Cooper pairs of them proportional to h_{eff} are obvious candidates concerning energy storage. The value of $h_{eff} \simeq 10^{14}$ guaranteeing the energies of dark EEG photons are in the range of bio-photon energies would mean that storage as cyclotron energies is very effective and the liberated energy quanta can directly induce molecular transitions essential for bio-chemical reactions.
2. The liberation of metabolic energy could take place in a phase transition in which p-adic length scale increases and h_{eff} is reduced in such a way that the length of flux tubes is not changed. This induces a coherent quantum transition in the sense that large number of particles can liberate cyclotron energy as cyclotron energy scale is reduced in the reduction of magnetic field strength. As protons flow from thinner flux tube with smaller h_{eff} to thicker one, similar reduction of cyclotron energy takes place and the energy is liberated, and would

be received by ATP synthase to form ATP from ADP. This mechanism could be universal and at work also in other situations.

3. At quantitative level the identification $h_{eff} = h_{gr}$ of gravitational Planck constant with $h_{eff} = n \times h$ at microscopic level at least is an attractive hypothesis [K117, K94]. Gravitational Planck constant can be expressed as $\hbar_{gr} = GMm/v_0$, where v_0 is taken to be the rotational velocity of Earth. Assuming this for Cooper pairs of rotating super-conductor explains the gravimagnetic anomaly claimed by Tajmar et al [E5, E7]. It also predicts a universal energy spectrum of dark cyclotron photons in the range of bio-photon energies and gives thus support for the hypothesis that dark EEG photons decay to bio-photons. The metabolic energy quantum for proton of order 5 eV is consistent with the identification as cyclotron energy difference for proton over mitochondrial membrane. The hypothesis $h_{em} = h_{eff} = h_{gr}$ makes also sense for the nano-motor defined by ATP synthase transforming ADP to ATP. The interpretation would be that this condition makes possible the reconnection of electromagnetic and gravitational flux tubes.

One can imagine also different scenario involving phase transition changing the value of h_{eff} assignable to atoms. TGD indeed predicts also small values of h_{eff} . $h_{eff} = h_{em}$ would hold true when em interaction becomes non-perturbative. In this case NE would be short ranged and associated with atomic/molecular systems with nonstandard value of h_{eff} .

1. For dark atoms the scale of binding energy behaves like $1/h_{eff}^2$ and is thus reduced for dark atoms [K36, K37, K38, K39]. The creation of dark atoms would require metabolic energy. This metabolic energy could also be liberated as dark atoms transforms to ordinary atom. Metabolic electrons could be associated with dark atoms and also the dark atoms in nutrients could provide metabolic energy driving protons through the mitochondrial membrane against potential gradient and transforming ADP to ATP contains high energy phosphate bond, which would actually correspond to the presence of dark (say hydrogen -) atom. Phosphate containing the dark atom would carry the negentropic entanglement or be accompanied by dark magnetic flux tube.
2. Phosphorylation and de-phosphorylation could be interpreted in terms of reconnection of flux tubes so that the dark proton associated with phosphate is transferred to the acceptor molecule. I have proposed that the deeper meaning of metabolism is transfer of negentropic entanglement (NE). The reconnection of flux tubes would transfer NE between ATP and third party to NE between acceptor molecule and third party. There is a large number of alternative identifications for NE. It could be short range entanglement associated with $h_{eff} = h_{em}$ assignable to electron and nucleus of dark atoms, to pairs of atoms or molecules, or very long range entanglement between molecule and large scale structure with size scale of Earth or even galaxy and associated with $h_{eff} = h_{gr}$. Both forms of NE might be involved and distinguish between two evolutionary levels.
3. Short ranged NE could be associated with dark atoms for which the scale of binding energy behaves like $1/h_{eff}^2$ and is thus reduced for dark atoms [K36, K37, K38, K39]. The creation of dark atoms would require metabolic energy. This metabolic energy could also be liberated as dark atoms transforms to ordinary atom. The dark atoms in nutrients transforming to ordinary atoms could provide the metabolic energy driving protons through the mitochondrial membrane against potential gradient and transforming ADP to ATP contains high energy phosphate bond, which would actually correspond to the presence of dark (say hydrogen -) atom. Phosphate containing the dark atom would carry the NE or be accompanied by dark magnetic flux tube. The transfer of NE would mean its disappearance followed by reappearance and it could happen that $h_{eff}/h = n$ is reduced in the process.
4. The simplest view about photosynthesis would be that the absorption of solar photons excites some atoms to dark states and that nutrients contain these dark atoms as stable enough entities. The contamination of nutrients could mean the decay of these dark atoms to the normal states.

Exclusion zones as prebiotic cells

TGD based model [L25], [K91] for Pollack's findings [L25] provides further guidelines.

1. Pollack *et al* discovered what they call exclusion zones and fourth gel like phase of water. The phenomenon occurs when water is bounded by gel and is irradiated with say visible light. Exclusion zones are negatively charged regions of water with positively charged environment. They act like batteries and have rather exotic properties. For instance, various impurities are repelled from exclusion zone.
2. The observed $H_{1.5}O$ stoichiometry implies that every fourth proton or hydrogen atom is dark and is transferred to the region outside the negatively charged exclusion zone. If only protons are transferred, very high negative charge density is generated. The size of the exclusion zone varies up to $100\ \mu\text{m}$ and is in the range of cell sizes.
3. Dark matter corresponds in TGD Universe to phases with nonstandard value of Planck constant: $h_{eff} = n \times h$ phases at the "magnetic body" of the system (negatively charged region now). Magnetic body corresponds in Maxwell's theory to the magnetic fields generated by the system. Magnetic body consists of flux quanta (flux tubes and sheets).
4. If dark protons with say size scale of atomic size reside at flux tubes, one can assume that they form strings giving rise to dark atomic nuclei. Also ordinary nuclei consist of strings of dark protons and strings of neutrons. Various impurities are transferred from exclusion zone to the exterior suggesting that they become dark particles at magnetic flux tubes.
5. The quantum states of dark protons consist of 3 quarks and a simple model involving rotational symmetry around the axis of dark proton string predicts that the states of dark proton can be arranged into groups which correspond to DNA, RNA, amino-acids and possibly also tRNA molecules. Vertebrate genetic code can be realized as a natural correspondence between DNA/ RNA and amino-acids [L3, K58].
6. Negatively charged EZ could define a pre-biotic cell so that water would be a primitive pre-biotic life form. The voltage would be the analog of the resting potential. The transformation of dark protons to ordinary ones would liberate metabolic energy so that primitive metabolism and photosynthesis would be realized. One can also consider a more general possibility that cyclotron energies are different at flux tube portions in the interior and exterior of the EZ analogous to cell membrane. This would increase the value of the metabolic energy currency by adding to Josephson energy ZeV the difference of dark cyclotron energies proportional to h_{eff} . One expects that dark counterparts of basic bio-polymers are still present in living matter and play a fundamental role.

What might happen in $\text{ADP} \rightarrow \text{ATP}$ process?

The identification of the exclusion zone with magnetic body as a basic structure allows to speculate about what might happen in $\text{ADP} \rightarrow \text{ATP}$ process and how ATP might store metabolic energy.

1. The strings of dark protons [K58] would be analogous to basic bio-polymers serving as the basic fuel of metabolics hydrolysed in metabolism. Basic biopolymers tend to be negatively charged and could therefore be accompanied by dark proton strings and the liberated metabolic energy might be stored by these strings as cyclotron energy and as Coulomb energy.
2. The simplest guess is that metabolism has developed from the transformation of dark protons to ordinary ones as the analog of EZ transforms back to ordinary water and potential difference disappears. One can also consider generalizations of this picture. A phase transition reducing h_{eff} and increasing p-adic scale such that the size scale of the flux tube remains fixed but cyclotron energy is reduced. This phase transition could also effectively accompany the flow of protons through the boundary of EZ if h_{eff} is smaller and p-adic scale longer at the other side. This mechanism could be still at work at the level of mitochondria for dark protons.

3. The notion of high energy phosphate bond is somewhat mysterious. ATP is negatively charged and one can wonder whether it could be accompanied by EZ assignable to the negatively charged phosphates. Also DNA strands and many other biomolecules carry negative charge due to the phosphates. Could the metabolic energy be stored to the magnetic body of ATP or of phosphate and eventually liberated by flow of protons to flux tubes with weaker magnetic field?

One can ask why the rotation of ATP synthase motor is necessary. Could the centrifugal acceleration drive dark particles to the magnetic body or keep them there thus stabilizing the dark phase? The dark protons at the magnetic body rotating with the system would remain to magnetic body and would avoid transition to ordinary protons if it is induced by the vicinity of ordinary protons serving as seeds for phase transition. If this interpretation is in the right direction, the rotating magnetic systems might provide a way to create dark matter [K12].

Energy metabolism as transfer of negentropic entanglement?

Negentropic entanglement (NE, see **Fig.** <http://tgdtheory.fi/appfigures/cat.jpg> or **Fig. ??** in the appendix of this book) is 2-particle property (or more generally $n > 1$ -particle property). One can argue that this is not consistent with the naïve idea about systems carrying NE as a resource analogous to metabolic energy. If negentropy transfer is behind metabolism and if one accepts this objection, one must ask whether metabolism actually corresponds to a transfer of NE between nutrient A and some fixed system B so that NE transforms to that between receiver R and same fixed system B? If so, could this B correspond some higher collective level of consciousness perhaps identifiable as gravitational Mother Gaia (MG) as suggested by the success of $h_{gr} = h_{eff}$ hypothesis at microscopic level?

1. Negentropic entanglement (NE) would be transferred. Nutrients would be negentropically entangled with something very crucial for life. MG is a good candidate in this respect. Even Sun can be considered. Gravitational NE with MG would make possible dark EEG, etc... Basic formula is $h_{gr} = GMm/v_0$, v_0 the rotational velocity at surface at the surface of Earth.
2. Formula generalizes to em case: $h_{em} = Z_1 Z_2 e^2 / v_0$ and would apply to ATP synthase being consistent with $h_{gr} = h_{em} = h_{eff}$. Em flux tubes could reconnect with gravitational flux tubes for $h_{gr} = h_{em}$.
3. Nutrient-MG NE can be transformed to molecule-MG NE by the sequence $N-MG \rightarrow P-MG \rightarrow ATP-MG \rightarrow R-MG$ (N for nutrient, R for receiver).
4. The basic mechanism would be the reconnection of magnetic U-shaped loops associated with various molecules serving as kind of tentacles: N/P/ADP/R would have this kind of loops.

One can represent a critical comment. The notion of personal magnetic body (PMB) controlling biological body (BB) is central for TGD inspired theory of consciousness. The above argument does not involve it at all. Can the notion of PMB be therefore consistent with MG hypothesis? Or is PMB in some sense part of the magnetic body of MG - say in the sense that the flux tubes of PMB could be inside flux tubes of MG? Mystics would perhaps equate MG with PMB but this leads to paradoxes.

1. An attractive guess is that $h_{em} = h_{gr}$ holds true for PMB so that it can interact with MG by forming reconnections. Nutrients are dead but have NE with MG so that metabolism allows BB to have NE with MG.
2. How PMB could generate NE with BB? Could it reconnect with the flux tube pairs connecting MG with BB? Do both MG and PMB have NE with BB during life-time. What happens in biological death?: does the NE between PMB and BB transform to that between BB and MG again and only the NE between PMB and MG remains? This would conform with what spiritual teachings say.

3. If the answers to these questions are “yes”, the basic purpose of metabolism would be the transformation of gravitational NE between MG and nutrients to that between MG and biomolecules. Magnetic bodies would “steal” part of this NE by reconnecting between MG and BB to that between PMB and BB: note that this process would be something new besides molecular metabolism and could be interpreted as a higher level metabolism. All this would be basically transfer of information from collective level of consciousness to lower levels to be processed and further enriched and to be returned back to MG in biological death: nothing would be lost! Biological death itself would be reconnection transforming flux tube bonds to PMB to bonds to MG.

Could electrons serve as nutrients?

The New Scientist article (see <http://tinyurl.com/ybd4g2k1>) about bacteria using electrons as nutrients is very interesting reading since the reported phenomenon might serve as a test for the TGD inspired idea about metabolism as a transfer of negentropic entanglement (NE, see **Fig. <http://tgdtheory.fi/appfigures/cat.jpg>** or **Fig. ??** in the appendix of this book) at fundamental level discussed in [K94] (see <http://tinyurl.com/yat9bx9j>).

1. NE is always between two systems: nutrient and something, call it X . The proposal inspired by a numerical coincidence was that X could be what I have called Mother Gaia. X could be also something else, say personal magnetic body. The starting point was the claim that the anomalously high mass of electronic Cooper pair in rotating superconductor (slightly larger than the sum of electron masses!) could be due to a gravimagnetic effects which is however too strong by a factor 10^{28} . This claim was made by a respected group of scientists. Since the effect is proportional to the gravimagnetic Thomson field proportional to the square of Planck constant, the obvious TGD inspired explanation would be $h_{eff} \simeq 10^{14}$ (see <http://tinyurl.com/yb7rsct5> and <http://tinyurl.com/yat9bx9j>).
2. Gravitational Planck constant $\hbar_{gr} = GMm/v_0$, v_0 typical velocity in system consisting of masses $M \gg m$ and m was introduced originally by Nottale and I proposed that it is genuine Planck constant assignable to flux tubes mediating gravitational interaction between M and m . In the recent case v_0 could be the rotating velocity of Earth around its axis at the surface of Earth.
3. For electron, ions, molecules, .. the value of \hbar_{gr} would be of the order of 10^{14} required by the gravimagnetic anomaly and is also of the same order as $h_{eff} = n \times h$ needed by the hypothesis that cyclotron energies for these particles are universal (no mass dependence) and in the visible and UV range assigned to biophotons. Biophotons would result from dark photons via phase transition. This leads to the hypothesis $h_{eff} = \hbar_{gr}$ unifying the two proposals for the hierarchy of Planck constants at least in microscopic scales.

Thanks to Equivalence Principle implying that gravitational Compton length does not depend on particle's mass, Nottale's findings can be understood if \hbar_{gr} hypothesis holds true only in microscopic scales. This would mean that gravitation in planetary system is mediated by flux tubes attached to particles. One non-trivial implication is that graviton radiation is dark so that single graviton carries much larger energy than in GRT based theory. The decay of dark gravitons to ordinary gravitons would produce bunches of ordinary gravitons rather than continuous stream: maybe this could serve as an experimental signature. Gravitational radiation from pulsars is just at the verge of detection if it is what GRT predicts. TGD would predict pulsed character and this might prevent its identification if based on GRT based belief system.

4. In the recent case the model would say that the electrons serving as nutrients have this kind of negentropic entanglement with Mother Gaia. $\hbar_{gr} = h_{eff}$ would be of order 10^8 . Also in nutrients electrons would be the negentropically entangled entities. If the model is correct, nutrient electrons would be dark and could also form Cooper pairs. This might serve as the eventual test.

This is not the only model that one can imagine. TGD predicts also small values of h_{eff} . $h_{eff} = h_{em}$ would hold true when em interaction becomes non-perturbative. In this case NE

would be short ranged and associated with atomic/molecular systems. At this moment one cannot exclude the possibility that only short range NE is involved with living matter.

Short ranged NE could be associated with dark atoms for which the scale of binding energy behaves like $1/h_{eff}^2$ and is thus reduced for dark atoms [K36, K37, K38, K39]. The creation of dark atoms would require metabolic energy. This metabolic energy could also be liberated as dark atoms transforms to ordinary atom. Metabolic electrons could be associated with dark atoms and also the dark atoms in nutrients could provide metabolic energy driving protons through the mitochondrial membrane against potential gradient and transforming ADP to ATP contains high energy phosphate bond, which would actually correspond to the presence of dark (say hydrogen -) atom. Phosphate containing the dark atom would carry the negentropic entanglement or be accompanied by dark magnetic flux tube.

Electrons are certainly fundamental for living matter in TGD Universe.

1. Cell membrane is high T_c electronic super-conductor [K94]. Members of Cooper pairs are at flux tubes carrying opposite magnetic fields so that the magnetic interaction energy produces very large binding energy for the large values of h_{eff} involved: of the order of electron volts! This is also the TGD based general mechanism of high T_c superconductivity: it is now accepted that anti ferromagnetism is crucial and flux tubes carrying fluxes at opposite directions is indeed very antiferromagnetic kind of thing.
2. Josephson energy is proportional to membrane voltage ($E_J = 2eV$) is just above the thermal energy at room temperature meaning minimal metabolic costs.
3. Electron's secondary p-adic time scale is .1 seconds, the fundamental biorhythm which corresponds to 10 Hz alpha resonance.

9.2.6 Humble Origins Of DNA As Nutrient - Really Humble?

I received an interesting link (<http://tinyurl.com/ybv8xu9u> DNA_May_Have_Had_Humble_Beginnings_As_Nutrient_Carrier_999.html) about the indications that DNA may have had rather humble beginnings: it would have served as a nutrient carrier [I116]. Each nucleotide in the phosphate-deoxyribose backbone corresponds to a phosphate and nutrient refers to phosphate assumed to carry metabolic energy in high energy phosphate bond.

In AXP, X=M, D, T the number of phosphates is 1, 2, 3. When ATP transforms to ADP, it gives away one phosphate to the acceptor molecule which receives thus metabolic energy. For DNA there is one phosphate per nucleotide and besides A also T, G, and C are possible.

The attribute "humble" reflects of course the recent view about the role of nutrients and metabolic energy. It is just ordered energy what they are carrying. TGD view about life suggest that "humble" is quite too humble an attribute.

1. The basic notion is potentially conscious information. This is realized as negentropic entanglement for which entanglement probabilities must be rational numbers (or possibly also algebraic numbers in some algebraic extension of rationals) so that their p-adic norms make sense. The entanglement entropy associated with the density matrix characterizing entanglement is defined by a modification of Shannon formula by replacing the probabilities in the argument of the logarithm with their p-adic norms and finding the prime for which the entropy is smallest. The entanglement entropy defined in this manner can be and is negative unlike the usual Shannon entropy. The interpretation is as information associated with entanglement. Second law is not violated since the information is 2-particle property whereas as Shannon entropy is single particle property characterizing average particle.

The interpretation of negentropic entanglement is as potentially conscious information: the superposition of pairs of states would represent abstraction or rule whose instances would be the pairs of states. The larger the number of pairs, the higher the abstraction level.

2. The consistency with standard quantum measurement theory gives strong constraints on the form of the negentropic entanglement. The key notion is that if density matrix is proportional to unit matrix, standard measurement theory says nothing about the outcome of measurement and entanglement can be preserved. Otherwise the reduction occurs to one of

the states involved. This situation could correspond to negentropic 2-particle entanglement. For several subsystems each subsystem-complement pair would have similar density matrix. There is also a connection with dark matter identified as phases with non-standard value $h_{eff} = n \times h$ of Planck constant. n defines the dimension of the density matrix. Thus dark matter at magnetic flux quanta would make living matter living.

In 2-particle case the entanglement coefficients form a unitary matrix typically involved with quantum computing systems. DNA-cell membrane system is indeed assumed to form a topological quantum computer in TGD framework. The braiding of magnetic flux tubes connecting nucleotides with lipids of the cell membrane defines topological quantum computer program and its time evolution is induced by the flow of lipids forming a 2-D liquid crystal. This flow can be induced by nearby events and also by nerve pulses.

Side-step: Actually pairs of flux tubes are involved to make high temperature superconductivity possible with members of Cooper pairs at flux tubes with same or opposite directions of spins depending on the direction of magnetic field and thus in spin $S = 0$ or $S = 1$ state. For large value of Planck constant $h_{eff} = n \times h$ the spin-spin interaction energy is large and could correspond in living matter to energies of visible light.

3. Negentropy Maximization Principle (NMP, [K73]) is the basic variational principle of TGD inspired theory of consciousness. NMP states that the gain of negentropic entanglement is maximal in state function reduction so that negentropic entanglement can be stable.
4. NMP guarantees that during evolution by quantum jumps recreating the Universe (and sub-Universes assignable to causal diamonds (CDs)) the information resources of Universe increase. Just to irritate skeptics and also to give respect for the ancient thinkers I have spoken about “Akashic records”. Akashic records can be said to form books in a universal library and could be read by interaction free quantum measurement preserving entanglement but generating secondary state function reductions providing conscious information about Akashic records defining also a model of self.

Side-step: Self can be identified as a sequence of state function for which only first quantum is non-trivial at second boundary of CD whereas other quantum jumps induce change of superposition of CDs at the opposite boundary and states at them). Essentially a discretized counterpart of unitary time development would be in question. This allows to understand how the arrow of psychological time emerges and why the contents of sensory experience is about so narrow a time interval. Act of free will corresponds to the first state function reduction at opposite boundary and thus involves change of the arrow of psychological time at some level of self hierarchy: this prediction is consistent with the Libet’s findings that conscious decision implies neural activity initiated before the decision (“before” with respect to geometric time, not subjective time).

In this framework the phosphates could be seen as ends of magnetic flux tubes connecting DNA to cell membrane and mediating negentropic entanglement with the cell membrane. DNA as topological quantum computer vision conforms with the interpretation DNA-cell membrane system as “Akashic records”. This role of DNA-cell membrane system would have emerged already before the metabolic machinery, whose function would be to transfer the entanglement of nutrient molecules with some bigger system X to that between biomolecules and X . Some intriguing numerical coincidences suggest that X could be gravitational Mother Gaia and flux tubes mediating gravitational interaction with nutrient molecules and gravitational Mother Gaia could be in question [K88]. This brings in mind Penrose’s proposal about the role of quantum gravity. TGD is indeed a theory of quantum gravity predicting that gravitation is quantal in astrophysical length scales.

9.3 Does Constant Torque Induce A Phase Transition Increasing The Value Of Planck Constant?

The hierarchy of phases with effective value of Planck constant coming as an integer multiple of the ordinary Planck constant and interpreted as dark matter is crucial in the TGD inspired model

of living matter. The challenge is to identify physical mechanisms forcing the increase of effective Planck constant h_{eff} (whether to call it effective or not is to some extent matter of taste). The work with certain potential applications of TGD led to a discovery of a new mechanism possibly achieving this. The method would be simple: apply constant torque to a rotating system. I will leave it for the reader to rediscover how this can be achieved.

The importance of the result is that it provides strong mathematical motivations for zero energy ontology (ZEO), causal diamonds (CDs), and hierarchy of (effective) Planck constants [K27]. Quite generally, the results apply to systems with external energy feed inducing generalized force acting in some compact degrees of freedom. Living matter represents basic example of this kind of system. Amazingly, ATP synthase enzyme contains generator with a rotating shaft: a possible TGD based interpretation is that the associated torque forces the generation of large h_{eff} phases. This conforms with the proposal that the basic function of metabolism is to produce large h_{eff} phases making also possible negentropic entanglement [K73] and generation of “Akashic records” as negentropically entangled states which are approximately invariant under quantum jumps if they correspond to interaction free (approximately) measurements for the Akashic records [K99].

9.4 A Model For Brain Metabolism

Oxygen and glucose are absolutely essential for consciousness. Thus I find it somewhat astonishing that quantum consciousness theorists (with myself included!) have paid only a minor attention to the exceptional role of oxygen and glucose. The realization that the liberation of a usable energy and the generation of bound states giving rise to macroscopic coherence and binding mental images to larger mental images are two sides of the same coin encourages the hopes that one might understand why metabolism is so crucial for consciousness.

In the most conservative scenario the ordinary metabolism corresponds to a purely local liberation of energy whereas the generation of macroscopic bound states means a non-local liberation of usable energy and represents a new kind of metabolism involving time mirror mechanism (see **Fig.** <http://tgdtheory.fi/appfigures/timemirror.jpg> or **Fig.** ?? in the appendix of this book) and generalized four-wave interaction with the ensuing time non-locality and instantaneous generation of usable energy. Also ordinary metabolism might involve generation of macroscopic bound states and a non-local liberation of a usable energy as some paradoxical findings about energetics of neural activity suggest. Nanobiology has during last years demonstrated that existing Newtonian thinking does not be of much help in the understanding of the phenomena involved and might provide fascinating applications for the notion of bound state entanglement.

At the concrete level of models the TGD view about metabolism and consciousness would look like follows.

1. There are at least three important participants involved in the generation of conscious experience: the colony of red blood cells, the gap junction connected structures formed by astrocytes, and neurons: all these structures and their components can form bound state entanglement with each other.
2. Astrocytes serve as energy reserves of the brain and bound state entanglement allows a non-local liberation of the metabolic energy at the neuronal level. Part of this energy must go to the build-up of MEs serving as projectors to the sensory magnetic canvases at various levels of the hierarchy. The mysteriously low rate of the oxidative neuronal metabolism during a heightened neuronal activity might be partially due to the fact that the dissipation is very low, partially due to the fact that bound states are generated and binding energy is also liberated. Many-sheeted ionic flow equilibrium (supported by the findings challenging the notions of ionic channels and pumps [I125]) with non-dissipating supra currents generating evoked and invoked potentials might reduce dramatically the postsynaptic energy costs. Further support for this picture comes from a detailed model for the generation of MEs defining projectors to the sensory canvas explaining also the strange properties of the so called Brown’s gas obtained by electrolysis from water as well as from the explanation of the anomalies found already century ago by nobelist Irving Langmuir.
3. Astrocytes are coupled by motile “endfeet” to neurons and are known to be in intense communications with them. There are reasons to believe that neuronal data are transmitted

to the gap junction connected structures of astrocytes, synticiums [J43, J56]. Astrocytes have also “endfeet” to blood cells. Blood cells rush where the neuronal action but as already noticed, oxidative metabolism is very low during heightened neuronal activity. Blood cells are magnetic structures and blood records the direction of the gravitational force. Hence thus blood cell sub-colonies are ideal candidates for generating the projector MEs to to the sensory magnetic canvases. The pyramidal cells which also contain magnetic crystals are second candidate for the projectors and now cellular water takes the role of blood. These two sensory representations are good candidates for the representations of “internal milieu” (what it feels) and external world and body as seen by outsider (what it looks).

4. A general vision about how generalized motor control is performed from sensory canvas emerges as a by-product. The proposed realization is based on the generation of sound waves on blood vessels by MEs from the sensory canvas. These sound waves interact with astrocytes generating Ca^{++} waves and induce “internal speech” serving as high level symbolic language in turn transformed into nerve pulse patterns by the memetic code. As a matter fact, entire hierarchy of “internal speeches” is predicted and correspond effectively the Fourier decomposition of MEs to frequency components by various parts of brain and body at various length scales. The scaling law from homeopathy serves as a guideline leading to the identification of detailed mechanisms for how this Fourier analysis happens.

9.4.1 Metabolism In Brain

In order to detail the general vision about the relationship between metabolism and consciousness, it is good to learn the basic facts about the energetics of brain. At the level of biological body there are three interacting systems: blood flow, astrocytes, and neurons. In the sequel I provide the view of an innocent novice about these three systems and their interactions and try to identify anomalies serving as signatures for the presence of non-local energy liberation mechanisms. I hope that the power of the general vision to unify might compensate the un-precision at the level of details.

In the classical world the understanding of the energy and information currents between these three systems would be enough. In TGD framework the presence of the dark matter hierarchy of magnetic bodies changes the situation profoundly since magnetic bodies become key participants of the energy metabolism. Time mirror mechanism provides a tool of both remote metabolism, long term memory, and quantum control. The reduction of the charged entanglement induced by W MEs affects local charge densities, which induces ordinary currents. This quantum control mechanism would rely to the exotic ionization of dark bosonic ions, in particular Ca^{++} ions, and the appearance of Ca^{++} waves in a very wide velocity range suggests the universality of this mechanism. W entanglement provides also a mechanism making possible sharing of mental images: this mechanism could be realized during nerve pulse propagation, and could make also possible also quantum parallel superpositions of nerve pulse patterns and hence quantum computation like activities [K4, K96].

Magnetic bodies as key participants brain of metabolism

Dark matter hierarchy leads to a new view about neuronal metabolism where communications to and control by the magnetic bodies are key utilizers of the metabolic energy.

1. Many-sheeted ionic flow equilibrium

The prevailing view about neuronal metabolism is that in the resting situation most of the metabolic energy goes to the maintaining of the concentration gradients by pumping ions between cell interior and exterior. There is however empirical evidence challenging the notion of ionic pumps and channels and there are also theoretical objections against them [I125].

The notion of the many-sheeted ionic flow equilibrium relies on these observations. The basic idea is that cell interior and exterior correspond to disjoint space-time sheets and that the join along bonds connecting them appear and disappear by a quantum mechanism. Join along boundaries bonds allow the ionic currents to flow as non-dissipative quantal currents. This explains why ionic currents can flow during metabolic deprivation, the observed quantum character of these currents,

and completely unexpected independence of the ionic currents on the details of the membrane in question [K24, K96].

Channels and pumps are identified as sensory receptors detecting ions and also membrane voltage allowing neuronal and cell membrane to perceive the nearby environment chemically. Only a negligible amount of ionic currents would flow through them. Synaptic contacts would play same role but now the primary sensory input would arrive from the external world. Note that also supra currents could provide metabolic energy as well as momentum when it leaks to the atomic space-time sheet and in the model of ATP this mechanism is assumed to be behind coherent locomotion.

2. The new view about neuronal metabolism

If this picture is correct, the view about the neuronal and also cellular metabolism changes profoundly.

1. The concentration of cytochrome oxidase measures the local metabolic activity and correlates with the number of synapses rather than with the number of neurons. This suggests that postsynaptic activity, whatever it is, is responsible for the use of metabolic energy.
2. In the usual book-keeping the ionic currents associated with the action potentials and post-synaptic activity would be main users of the metabolic energy. Cation fluxes increase by a factor of 100-1000 during action potential but they last for only 1 millisecond. Evoked and invoked postsynaptic potentials are accompanied by cationic fluxes which are 10 per cent of the range for action potentials but last for 10-1000 longer. If these ionic currents flow almost without dissipation the situation changes profoundly.
3. The cell membrane Josephson junctions generating coherent IR photons and the scaled up dark variants of this Josephson junction (in particular ordinary EEG) generating photons with the same energy scale would become main utilizers of the metabolic energy. This metabolic energy would be needed to the communication of sensory input to the hierarchy of magnetic bodies using dark photons with energies above the thermal threshold and the motor response of the magnetic body utilizing negative energy photons in same energy range would also require metabolic energy.
4. Metabolism is needed also for the synthesis, transport and recycling of the neurotransmitters. If these activities are control by neuronal magnetic body, they could proceed by a sequence in which neuronal magnetic body sucks energy from the motor instrument and this sucks energy from mitochondria or directly from glial cells. This “repeated stealing” of energy does not look very attractive ethically but the monstrosities that we see in nature documents are in spirit with this hypothesis.

The three metabolic pools in brain

Brain metabolism [J110, J26, J34] forms 20 per cent of the total metabolism during wake-up state. There are three interacting systems: neurons, glial cells (astrocytes) and red blood cells. There are three metabolic pools corresponding to glutamate- and GABA-ergic neurons and glutamine-ergic astrocytes (X-ergic means that neuron uses neural transmitter X in synaptic transmission). The oxidative metabolism of the glutamate-ergic neurons is estimated to be roughly 70-80 per cent of the brain metabolism. The rate of the oxidative metabolism correlates with the glutamate production rate which could also mean that oxidative metabolism corresponds only to what happens in axons. The metabolism of the GABA-ergic neurons and glutamine-ergic astrocytes contribute both 10 per cent to the total brain metabolism.

Astrocytes signal glutamate-ergic neurons using glutamine as a transmitter: in neurons it is transformed to glutamate used in turn to generate de-polarization of astrocytes followed by Ca^{++} waves serving as a signalling mechanism inside astrocytes. Glutamate is in turn utilize glutamine by astrocytes. This gives rise to glutamate-glutamine cycle. The rate for the transformation of glutamine to glutamate as well as the rate of the anaerobic metabolism of the astrocytes in this glutamine-glutamate cycle correlate with the rate of the metabolism of glutamate-ergic neurons.

Glutamine part of the cycle could be identified as a motor control of neuron group performed by magnetic body with the mediation of astrocyte syntica whereas glutamate part could correspond to a sensory input from neuron groups to astrocyte syntica to magnetic body.

Metabolic anomalies

There exists actually no consensus view about neuronal metabolism and there are many poorly understood and even mysterious looking aspects. The paradoxical finding is that much more oxygen rushes to coherently firing neuron groups than needed to satisfy the metabolic [J110]. What doubles the paradox is that the recent MRI studies show that the heightened neural activity uses only a very small amount of the extra oxygen [J75]. This would suggest that oxygen has some other function than providing metabolic energy in the standard manner.

That the cyclotron frequency of O_2^- radical is 9.4 Hz in Earth's magnetic field forces the question whether oxygen radicals could provide partially the metabolic energy used by $k_{em} = 4$ magnetic body as it performs bio-control by sending negative energy $k_{em} = 4$ dark photons in alpha band to the firing neuron group. The mechanism providing the metabolic energy would be the dropping from excited cyclotron states to lower cyclotron states. Free oxygen radicals would not be a mere nuisance in this framework.

Resolving the mystery of the ionic channels and pumps

The dark matter inspired view about metabolism is that ionic pumps and channels serve only as various kinds of ionic and voltage receptors of the magnetic body allowing it to receive information about the cellular environment. Only a minor fraction of ionic currents would flow through them. The main sink of the metabolic energy would be the photons and weak bosons associated with the generalized hierarchy of EEGs serving communication and control purposes of the hierarchy of magnetic bodies. The energy per ELF photon at $k = 4$ level of the dark matter hierarchy would be indeed above the thermal threshold so that already ordinary EEG would require a considerable expenditure of the metabolic energy.

The metabolic energy needed to build magnetic bodies

It is interesting to find what the proposed vision allows to conclude about the metabolism related to the construction of magnetic bodies.

1. The flux tube of Earth's magnetic field of length $L_e(167) = 2.52 \mu\text{m}$ with quantized magnetic flux has rest energy L/S and if the area is $S = L_e(167)^2$ the rest energy is $E(167) = .4844 \text{ eV}$, which is the energy released when single ATP molecule transforms back to ADP. The first question is whether the metabolism might take care about the regeneration of the magnetic flux tube structures, including also those associated with the magnetic sensory canvas. This does not seem to be the case: the reason is that magnetic flux tubes are expected to be rather stable structures and their continual generation would mean that the system would get drowned to magnetic flux tubes.

Part of the magnetic flux tube structure might however be generated during the growth period of the system. A rough estimate for the power needed to generate the magnetic canvas during this period is in order. The total rate of metabolism in a normal situation is about 10^4 kJ/day translating to $10^{12} m_p/\text{second}$, where $m_p \simeq 10^9 \text{ eV}$ is proton mass. Magnetic flux tube with a length of one Earth's circumference could thus be produced in 10 nanoseconds.

This estimate corresponds to the $k = 0$ level of dark matter hierarchy. For higher levels of dark matter hierarchy flux tubes are expected to define r -fold coverings of ordinary flux tube and have r -fold energy, $2 = 2^{k_d}$ for Mersenne hypothesis. Time scales are scaled up by r which would suggest that the buildup of magnetic bodies is a process occurring in the same time scale as the evolution of biological body and requires considerable metabolic resources.

2. MEs represent classical radiation escaping from the system and have a finite duration at a given space-time point. Therefore MEs can and must be generated continually. Buy now-pay later mechanism at DNA and possibly other levels could and probably does generate MEs at

least in alarm situation without metabolic costs. This corresponds to generation of bound states and the assumption that the energy costs must be paid later would mean that thermal noise sooner or later destroys the bound states. The classical estimate for the power involved with EEG gives an order of magnitude estimate about the metabolic energy involved.

Does brain delegate?

During wake-up state motor control from the magnetic body affects directly neuronal level. During sleep neurons the connection between astrocytes and neurons is off. This would suggest that during sleep red blood cells and astrocytes are involved in conscious processing of information using sensory representations about internal milieu generated mostly by red blood cells and feedback to the astrocytes. Also visual representations besides auditory ones are possible since red blood cells are also able to “see” bio-photons.

During wake-up period cortex takes care of a large amount of conscious information processing and the experience from what happens in human organizations suggests that during sleep this processing is delegated to the lower levels of the self hierarchy, in particular blood cell colony, while cortex is reserved for the purposes of the higher levels selves communicating and controlling at theta and delta EEG frequencies. Blood cells colonies of the entire body could be wake-up when we sleep. Of course, also other than blood cells could be in wake-up during sleep.

The bodily consciousness possibly activated during sleep would process the information from environment and wake-up cortex if needed. Red blood cells are indeed able to “see” at visible wave lengths and could provide for the body eyes allowing to perceive the radiation emitted by other living organisms (say predators). Also sounds could be transformed to em waves and amplified by the liquid crystals [D3] of the body acting as piezoelectrics. Blind sight and the strange feats of sleepwalkers might be due to the body vision and the role of red blood cells sensitive to visible light might be decisive.

One expects that red blood cells correspond to rather low level of dark matter hierarchy and thus rather high Josephson frequencies. One possibility are microwave frequencies assignable to the dynamics of protein conformations. Microwaves would serve as a correlate for the wake-up state of the red cell colony and cells in general.

While constructing a model for taos hum [K98] , [I127] I learned that after sunset there appears a radio static which has a biological origin and correlates strongly with taos hum [I127]. I identified this static as the analog of EEG for the sensory canvases associated with cells and proposed that the emergence of this radio static means wake-up at cellular level. The painful experience of taos hum presumably related to microwave hearing and inducing fatigue could be understood as a failure of the electromagnetic immune system to prevent the sucking of metabolic energy by other organisms using phase conjugate $k_{em} = 1$ radio waves. The radio noise generated by computers and other sources of radio waves need not cause troubles since these radio waves are expected to correspond to $k_{em} = 0$ and positive energy photons. To test this hypothesis, one could look whether a radio static analogous to EEG sets on after sunset and disappears after sunrise as the observations about taos hum suggest.

9.4.2 Astrocytes And Quantum Control Of Brain

Astrocytes

Astrocytes form 50 per cent of the total number of brain cells whereas neurons make only 10 per cent. The view about the function of astrocytes has changed dramatically during the last half decade thanks to the progress in the experimental side. The earlier view was that astrocytes have only two roles: they are kind of a motile skeleton of brain keeping neurons on place and serve as energy stores of brain. The new view is that astrocytes support, monitor, integrate and regulate neuronal activity [J56].

The existing understanding about astrocytes combined with TGD views encourages to think that astrocytes, neurons and red blood cells form kind of a “holy trinity” in which astrocytes allow the magnetic bodies to perform motor control in very general sense. In computer metaphor according to which me is computer sitting at its own terminal astrocytes correspond to the computer keyboard used by magnetic body corresponding to $k_{em} = 5$ level from the frequency of Ca^{++} waves. Red blood cells *resp.* neurons in turn project somatosensory sensory input *resp.* sensory

input from external world to the magnetic body with blood brain barrier representing the boundary between body and external world. Blood cells would represent somatosensory information about body including the orientation of the body whereas external world and third person view about body would be represented by neurons.

1. Basic facts about astrocytes

Astrocytes have typically a stellar shape with size of at least 10 micro-meters. Astrocytes form gap junction connected structures, synticiums, consisting of several millions of astrocytes and having sizes of order millimeter which is also the size of the coherently firing neuron groups in cortex. Astrocytes have processes or “endfeet” which envelope either groups or neuronal synapses or blood vessels. The neuronal endfeet make possible bi-directional communication between neurons and astrocytes and extended control of neuronal activity and modulation of neuronal synchronization. Also in case of capillaries control activity is possible and there is no good reason of not believing that also now bi-directional communications are possible.

The endfeet of astrocytes are motile and tend to move to the direction of the most active neurons. Astrocytes can also swell and the resulting change of the intercellular volume probably plays a control role since it changes both ion and transmitter concentrations.

Astrocytes and neurons communicate by neural transmitters. Astrocytes have large number of various receptors [J56] and there are good reasons to believe that astrocytes have complex chemical communications with neurons. For instance, glutamate-glutamine cycle involves reception of glutamate from neuronal synapses and chemical signalling by glutamine received by neurons. Glutamate induces de-polarization in the synticium of astrocytes propagating through it and accompanied by Ca^{++} wave. Ca^{++} is known to excite synaptic transmission, the dependence of transmission efficiency being proportional to the fourth power of Ca^{++} concentration. The sucking of Ca^{++} by Ca^{++} waves from synaptic regions near endfoot has thus inhibitory effect on them. The resulting Ca^{++} sooner or later returns Ca^{++} with opposite effect on synaptic efficiency. Now however the effect occurs simultaneously to a large number of neurons and this is believed to support and modulate neuronal synchronization.

The typical frequency for inhibitory-excitatory action is few times per minute, which suggests that Ca^{++} waves relate to the quantum control by $k_{em} = 5$ level of dark matter hierarchy for with Josephson period is about 3.6 minutes (.2 seconds for $k_{em} = 4$). Also short term memory relates to this level in the proposed vision [K44]. The scaling law $v = Lf$, with v taken to be the velocity of Calcium waves, L the size of synticium, and f the frequency of wave, deserves a testing. The law would give very small velocity of order mm/minute for $L = 1$ mm.

It has been proposed that a control circuit neurons-astrocytes-blood exists and that neurons could communicate for blood circuit the desire about increased blood flow. NO diffusion activated by a signal from neurons and in turn affecting blood circuitry via endfeet is one possibility. In TGD framework the control hierarchies magnetic body-astrocytes-neurons-blood flow and magnetic body-astrocytes-blood flow and sensory hierarchies resulting as their reversals seem natural.

2. The role of the astrocytes as metabolic reserves

Astrocytes act as the energy reserves of brain [J56] and should therefore act as metabolic censors limiting the intensity of conscious experiences expected to correlate directly with the amount of the binding energy liberated in the experience. The astrocyte-to-neuron ratio increases in the brains of the higher animals. The narrowest interpretation is that this reflects the increasing metabolic needs as higher levels of dark matter hierarchy emerge for each of which energies of dark EEG photons are above thermal threshold.

Astrocytes both synthesize, store and catabolize glycogen molecules. An obvious question is how this fuel is transferred from astrocytes to neurons. According to [J56] “It is very likely that there is astrocytic export of fuel substrates such as lactate to neurons”. The oxygen consumption in the activated neurons is very low [J75]. Is there *any* transport mechanism? Brain has probably not taken the risk of not getting fuel in case that the quantal transport mechanism based on the generation of negative energy bio-photons by neuron groups and received by astrocyte synticiums fail.

3. Astrocytes as an instrument of motor control

The known role of astrocytes as metabolic controllers and the gardener metaphor vision

about control as a selection of existing activities is consistent with the identification of the astrocytes as mediators of generalized motor control performed by magnetic $k_{em} = 5$ magnetic bodies.

This motor control would be high level control involving presumably symbolic representations: instead of detailed commands only names of complex motor activities are given. A reference wave generating a complex hologram is basic example of this kind of quantum control. This would suggest that the frequency of the carrier wave generation is rather low. Ca^{++} waves indeed appear with low frequencies of order few/minute. This frequency would be analogous to the kHz frequency associated of neural synchrony.

According to the TGD based models of EEG [K44] and nerve pulse [K96], gap junction connected structures can carry standing EEG waves and their scaled up variants. Also W MEs inducing charge entanglement are possible and would induce deviations from charge equilibrium and currents tending to compensate them. Ca^{++} would represent basic example of this and could be also seen as higher level variants of nerve pulses. In case of astrocytes $k_{em} = 5$ level suggests itself. Perhaps $k_{em} = 5$ magnetic body controls via synchronically firing neuron groups the metabolic activities of astrocyte groups. The scaled up variant of memetic code with the durations of memetic codon about $T = \lambda \times .1 \simeq 200$ s and single bit of codon about $T/127 \simeq 1.6$ seconds suggests itself.

If astrocytes are involved with the generalized motor control in the proposed manner, the astrocyte-neuron coupling should be on only during wake-up and turn off during sleep and relaxed states. This is indeed what has been observed according to [I47]. During sleep astrocytes would control mostly blood flow and receive sensory information also from blood flow through endfeet. This picture suggests that neuronal level delegates the responsibilities to the lower levels of the self hierarchy during sleep. This means that lower level magnetic bodies take care of bodily functions. The prediction is that astrocyte-neuron connection should be active during verbal dreams.

4. *The role of astrocytes in information processing*

During the last years it has become clear that astrocytes express most neurotransmitters and receptors expressed by neurons so that complex communications between astrocytes and neurons are expected to occur. The already mentioned glutamine-glutamate cycle involving the generation of Ca^{++} waves represents one example of astrocyte-neuron communications.

For instance, according to [J43] astrocytes have an active role in the information processing in the association areas, which have been identified as $k_{em} = 5$ levels of dark matter hierarchy in [K44], and the neuronal sensory information is represented at the level of astrocytes by patterns that activate Ca^{++} waves and that astrocytes in turn infotropically encode the information with resulting synchronously firing synaptic domains. The role of astrocytes associated with associative regions in the generalized motor control in TGD based model is as an interface transforming high level symbolic control signals (internal speech) from $k_{em} = 5$ level to lower level signals modulating nerve pulse activity via metabolic control.

Astrocytes also receive and gather information about blood flow through the endfeet in blood vessels and very probably also control the blood flow metabolically. One can ask whether sound waves in blood vessels or capillaries could allow the magnetic bodies associated with blood flow to communicate with astrocytes. Sound waves would be generated by MEs projecting to brain from sensory canvas coding the generalized motor commands as internal speech.

The holy trinity of blood, astrocytes, and neurons

The foregoing observations conflicting with the standard beliefs about how reductionistic and materialistic brain should function can be understood in the framework of TGD inspired theory of consciousness. I have already introduced the basic ideas of the model piece by piece but it is worth to develop it more systematically.

The computer sitting at its own terminal metaphor, the gardener metaphor, puppet on string mechanism, hologrammic control by reference waves, identification of features as synchronously firing neuron groups are the notions which lead to view that neurons, astrocytes, and blood form a "holy trinity" with sensory canvas representing the subjective me identifying itself with the physical body; astrocytes representing the computer terminal mediating motor control from the level of sensory canvas to brain level; neurons representing the processors of computer; and blood

and pyramidal cells (at least) generating the projector MEs to our sensory canvas. Of course, blood allows an entire hierarchy of sensory canvases.

Calcium waves as a tool of generalized motor control

The basic facts about Calcium waves are summarized in [J96]. Ca^{++} waves appear at all control levels in living matter and there are both mechanical, chemical, and electric mechanisms for the propagation. This suggests that the motor control mechanism based on MEs generating various kinds of waves at resonant frequencies is utilized by living matter in a very wide range of time and length scales. For a given mechanism of conduction the value of the velocity varies in rather narrow limits. The spectrum of the possible conduction velocities however spans nine orders of magnitude from few nm/s to about one m/s. The velocities of the ultraslow waves vary in the range 1-30 nm/s and they accompany developmental processes. Slow waves move with velocities 1-3 μ m/s. Fast waves move with velocities 10-30 μ m/s and move by reaction diffusion mechanism. Ultrafast waves move with velocities of about 15-40 cm/s and propagate electrically. In accordance with fractality, the ratio of the upper and lower limits for the velocities equals to 3 in all these cases.

If the entire astrocyte synticium is excited, the frequency f is smallest and should be of order few/minute: this together with the size estimate $L \sim 1$ mm for the size of the astrocyte gives estimate for the velocity v as $v \sim 16 \mu\text{m/s}$. This velocity belongs to the range of the fast Ca^{++} waves propagated by reaction diffusion mechanism. If only single astrocyte with size about 20 micro-ns responds, the frequency is of order $f \sim .8$ Hz. This would mean that the frequency interval to which astrocytes respond via Ca^{++} waves would be below the EEG range. Of course, it is highly plausible that there is entire hierarchy of responses in various frequency ranges and this would mean that the signal sent by ME would be effectively Fourier analyzed to various responses in various frequency ranges.

For ultrafast waves the frequency spectrum would vary roughly between .5 kHz and 50 kHz. The resonant kHz frequency involved with the synchronous firing of nerve pulse patterns belongs to this frequency range. Slow and ultraslow waves would correspond to frequency scales of order few/10 minutes and 1/month and interpretation in terms of biorhythms is suggestive. Interestingly, EEG range remains outside the frequency bands associated with Ca^{++} waves. This could mean a sharing of the frequency bands such that the frequency bands used for the generalized motor control do not have overlap with the frequency bands involved with the em MEs and responsible for projecting information to the sensory canvases.

Are astrocytes above neurons in the hierarchy?

The question is whether magnetic body uses astrocytes to control neurons or whether it uses neurons to control astrocytes. Or more precisely: does magnetic body use synchronously firing neuron groups to induce Ca^{++} waves in astrocyte synticia or use Ca^{++} waves to modulate neuronal firing? Astrocytes have “endfeet” on neurons and red blood cells and there are good reasons to believe that the end feet act as switches to control and integrate information. Astrocytes are present already in invertebrates so that there is not obvious answer to the question.

That astrocytes are above neurons in the hierarchy is suggested by following observations.

1. Since astrocytes are metabolic resources it would be very natural for magnetic body to suck energy directly from astrocytes. Also the fact that the frequency for the generation of Ca^{++} is few/minute, $k_{em} = 5$ is a natural identification for the dark matter level involved so that astrocytes seem to correspond to a higher level in dark matter hierarchy whereas nerve pulse activity would correspond to $k_{em} = 3$.
2. Astrocytes are known to “behave” (morphological change, motility, myelination, mitosis), which suggest a role that they are at higher level of hierarchy than neurons. The fraction of astrocytes in vertebrate brain increases at higher levels of the evolutionary hierarchy.
3. Microtubules were regarded as passive support structures for a long time. Astrocytes play a role analogous to micro-tubuli, which give rise to cytoskeleton playing a role of CNS of cell, take care of logistic functions, and also declarative memory in TGD framework [K96]. This encourages the view that astrocytes act as motor instruments of the magnetic body to

control the behavior of neurons and are involved with short term memories as the frequency of Ca^{++} wave generations suggests.

4. According to [I47], in deep relaxation states the switches from neurons to astrocytes are off whereas those from red blood cells are on. This would suggest that both neurons and red blood cells are at a lower level in the hierarchy. This would TGD based view suggests that astrocytes feet are essential link in the control of brain by magnetic body at $k_{em} = 5$ level of hierarchy. It is possible to assign to astrocytes also circadian rhythms that also $k_{em} = 6$ level is involved.
5. Since astrocytes are the metabolic stores of brain they naturally have a filtering role proposed also in [I47]. During altered states of consciousness this censorship temporally loosens and very intense euphoric moods can result. These “highs” however deplete sooner or later the metabolic reserves of astrocytes and are followed by “lows” as happens periodically in the manic-depressive disease. Quite generally, mental disorders could be accompanied by metabolic disorders at the level of astrocytes and due to the abnormalities in the blood flow.

Do higher levels of dark matter hierarchy use brain during sleep?

The absence of higher than delta bands in EEG spectrum during deep sleep is consistent with the assumption that dark photons in other than delta bands are absent. The frequencies around 1 Hz correspond to DNA cyclotron frequencies which suggests that quantum control of DNA activities occurs during deep sleep.

The metabolic energy spent by the brain to sensory and motor activities in the day-time would be used by magnetic bodies at $k_d > 46$ levels of dark matter hierarchy during sleep ($k_d = 46$ corresponds to 10 Hz region). For instance, $k_d = 54$ corresponds to the time scale of few minutes assignable to short term memory and to astrocyte-neuron interaction which is absent during deep sleep.

Structures responsible for circadian rhythms should involve $k_d = 65$ level. The master circadian pacemaker in mammals is considered to be the suprachiasmatic nucleus (SCN) of the hypothalamus containing heterogeneous population of neurons and glial cells: both express genes with circadian period [J111].

This would suggest that brains would be literally in a shared use. Higher level selves would use the brains of the average citizen mostly during night time whereas the brains of the people endowed with creative and meditative practices would be available to the higher level conscious entities also during daytime.

9.4.3 The Effects Of Endogenous Sound Waves As A Support For The Scenario

The effects of endogenous sound waves on consciousness provide some support for the suggested role of astrocytes as buffer between neurons and $k_{em} = 5$ magnetic body.

How the signals from magnetic body are transformed to control signals?

If the entire head of body receives the internal speech from $k_{em} = 5$ magnetic body, several amplification mechanisms are possible.

If this picture is correct, astrocyte syntica act as an interface between higher level symbolic and linguistic representation and neuronal representations. This would explain why the astrocyte/neuron ratio increases in higher organisms.

An interesting question relates to what differentiates between the natural sounds and spoken language. One might wonder whether hearing involves also the generation of internal speech involving the propagation of the speech sounds in blood vessels or some other cavities. Since body is liquid crystal it is also possible that muscles and collagen structures act as amplifiers of the weak sounds generated by MEs near vacuum extremals and carrying both em and Z^0 fields proportional to each other.

The size L of the excited part of the astrocyte synticum, which can be assumed to vary, and the propagation velocity v for the Ca^{++} waves, presumably controlled by the metabolic conditions,

determine the ELF frequency which can interact resonantly with the astrocyte and generate high frequency oscillations in it (MEs with frequencies at multiples of $f_h = c/L > 3 \times 10^{11}$ Hz and directly controlling the molecular level). Each astrocyte synticism could respond to a characteristic ELF or ULF frequency determined by its internal state and metabolism. It is conceivable that astrocytes can control also the Ca^{++} wave conductances of the gap junctions and thus the size and shape of the Ca^{++} conducting regions and the the ELF or ULF frequency that they respond to. The increase of the metabolic rate presumably increases the velocity of propagation for Ca^{++} waves.

Are sounds transformed to endogenous sounds to Ca^{++} waves?

The following considerations force to consider seriously the possibility that endogenous sounds transmitted from blood vessels to astrocytes are involved with hearing and create the sensation of hearing.

Various structures of biological tissue form collagen networks which are liquid crystals [I136] and thus piezoelectrics [D3] and allow the transformation of classical em and Z^0 waves to sound waves and vice versa. The weak sound waves might be amplified also by the walls of the blood vessels and capillaries and also by other muscles. This amplification mechanism is expected to work in entire length scale range ranging from body size to atomic length scales. For instance, if the carrier wave has kHz frequency, the wave giving rise to the neuronal synchrony, it has wave length of order head size, and the blood vessels and collagen networks inside head could serve as acoustic wave cavities.

There is empirical support for the endogenous amplification of sounds. Physiophonic sounds result in an electrical stimulation of the skin and speech represented in this manner is subjectively understood as speech: this could be due to the propagation of the sound signals through body. Note that meaningful signals coming from environment (created by say predator) can be transferred from skin directly to the astrocytes and stimulate wake-up. In light of this it would seem that deaf persons could learn to hear by feeding the sound signals directly to the body.

The sound waves could be mediated by blood to the endfeet of the astrocytes to blood vessels. Sound waves are indeed known to induce Ca^{++} waves [J43], which suggests that the mechanism explaining physiophonic hearing involves the transformation of endogenous sounds to Ca^{++} waves. Instead of magnetic body communicating internal speech as metabolic control signals to the astrocyte synticisms, the sound mediated from external world as physiophonic sound does the same. Also ordinary hearing could involve the transfer of sound waves of sounds as endogenous sounds to the synticisms such that spoken language would be transformed to Ca^{++} waves defining a representation experienced by the $k_{em} = 5$ magnetic body as speech.

That acoustic signalling could be present conforms with the fact the acoustic vibrations are indeed transformed to Ca^{++} waves. For instance, a very light blow in head generates acoustic waves which induce Ca^{++} wave patterns and can induce a loss of consciousness. The 1/minute frequency scale for Ca^{++} waves indeed suggests that the high level control using high level symbolic representation is in question.

Taos hum and endogenous sound waves

The victims of taos hum [I127] hear an intolerable humming sound with no identifiable external source containing also components reflecting the structure of acoustic environment could also involve the generation of physiophonic sounds. The most plausible identification of taos hum in terms of microwave hearing (amplitude modulation represents the sound) explains the failure of the attempts to identify the source for taos hum. The modulation of microwaves at audible frequencies would induce endogenous sounds which induce the sensation of hearing by generation Ca^{++} waves in astrocytes.

Taos hum starts immediately after sunrise and stops after sunset and seems to have biological origin. A possible explanation is that the magnetic bodies of (say) plant cells send $k_{em} = 1$ dark negative energy photons at microwave frequencies to satisfy their metabolic needs. An explanation for why the hum is intolerable and for extreme fatigue caused by it might be simple: the microwaves suck energy from its victim whose electro-immune system fails to insulate the body against this radiation.

Minor head trauma, epilepsy and endogenous sound waves

Minor head trauma and epilepsy provide a testing ground for the identification of endogenous sound waves as inducers of Ca^{++} waves in astrocytes. Minor head trauma does not cause any injury but is accompanied by a loss of consciousness. A possible explanation is that the endogenous sound waves contain the resonance frequency of head with high amplitude and induce a phase transition replacing $k_{em} = 5$ level with $k_{em} = 4$ level or even lower level so that consciousness at $k_{em} = 5$ level is lost.

One could try to understand also epileptic seizures in this framework. Hyperventilation increasing the oxygen content of blood is known to induce a petit mal in children. Petit mal is accompanied by the characteristic 3 Hz EEG rhythm in delta band. If motor control is mediated via the blood vessels as sound waves, the anomalously high concentration of oxygen in blood could somehow cause the petit mal.

1. In [J43] it is proposed that the mechanism involves the generation of Ca^{++} waves with 3 Hz frequency instead of few/minute frequency. Too much oxygen might induce a phase transition $k_{em} = 5 \rightarrow 4$ in which the frequency of Ca^{++} waves increases by a factor λ to about 3 Hz. This would also imply the increase of the velocity of propagation for Ca^{++} waves if scaling law $v = Lf$ is taken seriously. The resulting spatial and temporal incoherence would mean loss of consciousness at $k_{em} = 5$ level of the hierarchy.
2. This model for epilepsy is consistent with my own simultaneously frightening and fascinating night-time experiences in which the subjectively experienced volume of the sound of the refrigerator begins to get gradually amplified and I have a strong conviction that I am very near the border of an epileptic seizure and must wake-up fully as soon as possible. If theta and delta waves represent the frequency bands through which higher levels selves control our brain and receive sensory information, the amplification of the delta and theta waves above critical threshold could imply that these conscious entities take the cortex to their “possession” as also during sleep. Perhaps it is not an accident that prophets were often epileptics: trance could be an example of a situation in which higher level self operating at very low EEG frequencies uses brain to send motor commands and even communicate.

“Great experiences” and “blood consciousness”

I apologize for not saving the reader from the obligatory reference to my own strange visual experiences about complex hydrodynamics flow having usually a sink (“third eye”) in the middle of the visual when I close my eyes in a highly relaxed state. Perhaps this flow could relate to blood flow or magnetic flux tubes structures associated with the blood flow represented at “my” magnetic sensory canvas and represent also visually the state of the internal milieu. Also representation in other modalities are possible. A possible interpretation is that this flow somehow represents the state of the central nervous system with the sink (“third eye”) having identification as spine. An alternative possibility is that it represents directly the structure of the sensory magnetic canvas. The vortical structure of this flow could reflect the helical structure of the magnetic flux tubes associated with the sensory canvas and the canvas would be dynamical if this is the case.

The state of whole body consciousness accompanying sometimes this experience is characterized by the disappearance of the unpleasant noise usually present in the body and the generation of the thrill-in-spine sensation generated by good music and spreading over the entire body. Perhaps in this state both neuron and blood and possibly entire body are in a wake-up state simultaneously and use common sensory canvases at various levels. Maybe the entanglement with the higher levels of the self hierarchy makes possible the feed of the metabolic energy also from the external world in the form of electromagnetic energy carried by positive energy MEs during this kind of state.

I have also personal experiences about strange doubling of sound of breathing outwards just after wake-up or having run. What might happen is that the externally heard sound of breathing is heard as a copy slightly later. Perhaps the copy is nothing but the sound of breathing heard physiophonically. Another amusing (but not pleasant!) effect is to hear one’s own snoring when body still sleeps. The subjectively experienced intensity of the sound is much stronger than usually and experienced as an outsider: body is indeed effectively outsider when decoupled from the motor system. Also this sound could be interpreted as a physiophonic sound.

The well-known correlation of the skin conductivity with the mental state is consistent with the idea of body consciousness. Skin is an important factor in paranormal abilities such as telepathy (I have a personal experience in which I experienced what I believe to be a remote event as happening at my skin as a miniature version!), healing by touch, and psychokinetic abilities in which PK-able person holds some object in her hands and gradually releases it so that it remains “hanging” in the air.

9.5 Molecular Machines In Many-Sheeted Space-Time

Biophysics in nano scale looks like a miniature society populated by molecular citizens in their many duties. The basic problem is to understand how these molecular creatures are able to fight against thermal fluctuations so that their motion does not degenerate into mere Brownian randomness and how they can so effectively transform metabolic energy to a usable energy. The existing models rely on the so called ratchet principle: Brownian motors [I67, ?, I100] rectify Brownian motion and pick up from it only the thermal momentum which is in the desired direction.

The idea of Brownian motor is ingenious but many-sheeted space-time concept suggests even cooler idea: why not move on the non-atomic space-time sheets where there is no thermal motion so that the dissipation is practically nil and the only energy needed is basically the difference of the zero point kinetic energies needed to kick the molecular ant or its leg back to the atomic space-time sheet. Or expressing it in engineering terms: all moving parts of the quantum motors move at the non-atomic space-time sheets where the dissipation is minimal.

TGD provides also a new view about the energetics of molecular motors. The energetics of the living matter can be understood as being based on the ions flowing in an ohmic circuitry on the atomic space-time sheets (DC currents of Becker [J25]) and in a supra-current circuitry formed by the magnetic flux tubes. Energy is liberated in the dropping of protons and possibly other ions from atomic to super-conducting space-time sheets: the difference of the zero point kinetic energies is liberated as a usable energy. For chemical purposes this energy is emitted as a single photon whereas for mechanical purposes it could be liberated both as a single photon or as a cascade of ELF photons generated when high n cyclotron state of proton decays.

In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant \hbar_{eff} so that cyclotron energy would be liberated. In the following only the “dropping” option is discussed.

Amazingly, the velocities predicted by single photon mechanism for the motor enzymes turn out to be of correct order of magnitude! The zero point energy allows also ordinary dissipative motion if the proton drops to high n cyclotron state and decays by generating ELF MEs in turn building up a radiation pressure forcing the motion of the motor molecule. Thus one has two options, classical and quantum, for the molecular motors in TGD framework and both might be utilized depending on situation. The difference with respect to thermal ratchets in both cases is that the energy is liberated as a directed energy rather than mere heat energy rectified to a directed energy by ratchet.

The theory resolves several paradoxes, makes quantitatively correct predictions, and yields several pleasant surprises.

1. As far as molecular motors are considered both quantum and classical options seem to work. Quantum option is extremely predictive and easily killed by checking whether the velocities of motion for motor molecules scaling like $1/m$, m mass of the motor molecule, are what the theory predicts their precise values to be.
2. A new view about the real function of ATP molecule emerges: the questionable notion of the high energy phosphate bond is definitely wrong in TGD framework and the $F_0 - F_1$ machine generating ATP actually kicks up protons from super-conducting space-time sheets to atomic space-time sheets thus energizing them. Also other ions can serve as energy carriers and the DC currents of Becker [J25] would act as power lines.

3. The energy liberated in the dropping of a single proton from the atomic space-time sheet equals to energy about .5 eV liberated when single ATP molecule is consumed. On basis of the data about reaction kinematics [?] it however seems that also second proton drops down so that the liberated energy would be ~ 1 eV and too large by a factor of two. A possible explanation for the discrepancy is that the energy is liberated with equal probability as a single quantum and as a cascade of ELF photons and that the cascade of ELF photons are not taken into account in the usual book-keeping.

One can understand the duration of the ATP production step and the time scale for a single step of motion for molecular machines as being determined by proton's cyclotron frequency f_c about 300 Hz. The ratio $\Delta E/E_c$ of the zero point kinetic energy ΔE of proton at atomic space-time sheet to the proton cyclotron energy E_c equals precisely with the ratio $f_h/f_{ELF} = 2 \times 10^{11}$ of high and low frequencies appearing in the homeopathic scaling law stating that high and low frequencies implicating each other's presence [K58]. This supports the idea that both quantum and classical modes for the molecular motors are possible.

4. Ionic pumps and channels allow ions to run from atomic space-time sheets to magnetic flux tubes and vice versa: this resolves the paradox created by the empirical facts both supporting and challenging the existence of the ionic channels and pumps.
5. The TGD based vision about quantum neuron deepens considerably. The resting potential of the cell membrane (-63 meV) has an interpretation as a barrier preventing the flow of proton Cooper pairs from the $k = 139$ super-conducting space-time sheets in the cell interior to the magnetic flux tubes in the cell exterior. Nerve pulse is generated when the membrane potential drops below the critical value so that proton Cooper pairs start to flow from $k = 139$ super-conducting space-time sheet to the magnetic flux tubes of Earth's magnetic field. This induces the flow of various ionic currents, perhaps along same join along boundary contacts along which proton Cooper pairs flow in case of K^+ and Cl^- ions. EEG waves accompanying the propagation of the nerve pulse result when the high n cyclotron states of these ions decay. Also a novel view about the function of Ca_{++} waves emerges.

Already on basis of these examples, it seems to me that the understanding of what it is to be a proton in the many-sheeted space-time points out the Golden Road to the physics of the living matter. My hope is that these miracle like quantitative successes could help to break the reductionistic resistance against the new view about space-time and make possible collective effort to develop TGD based quantum theory of bio-systems.

9.5.1 TGD Inspired Questions And Ideas Relating To Coherent Locomotion

Does it make sense to store momentum?

An important aspect of doing work, not usually considered, is to generate or transfer momentum besides energy. An interesting question is whether also momentum could be stored just as energy is stored.

Chemi-osmotic phosphorylation involves the acceleration of the hydrogen ions in an electric field associated with an appropriate membrane structure. Part of the protonic momentum could be stored in a phosphate group related structure or directly to ohmic protonic currents perhaps identifiable as the DC currents of Becker [J25]. In photophosphorylation the storage of both photonic energy and momentum might be possible and the maximal momentum stored would be $p = E/c$ and by a factor $\sqrt{E/m_p} \sim 10^{-5}$ smaller than the maximal momentum $\sqrt{2m_p E}$ transfer in the chemi-osmotic phosphorylation.

If molecular storage mechanism of the momentum is same in both cases, the dominant fraction of the momentum must be absorbed by some larger structure, say by the catalyst cite or the appropriate membrane, in the chemi-osmotic phosphorylation. The rotation of the rotating shaft of the $F_0 - F_1$ machine [?] generating ATP could dissipate large fraction of the protonic momentum. Thus photosynthesis would be dominantly an energy transfer process whereas the hydrogen ion flow occurring in the chemi-osmotic phosphorylation is also a candidate for a momentum transfer or -generation process involved with locomotion and various transport processes.

An order of magnitude estimate for the maximal momentum transfer rate (acceleration) is obtained by assuming that the whole mass 50 g of the ATP of human body is recycled in 20 seconds and that phosphorylation of each molecule is accompanied by a generation of parallel momentum equal to $p = 3\sqrt{2E/m_p}$ when it receives the momentum of about 3 protons. In this manner one finds that the acceleration of the body with mass of 50 kg would be roughly $5 \times 10^{-2}g$, where $g = 10 \text{ m/s}^2$ is the acceleration of gravitation at the surface of Earth under average conditions. This value is certainly too low but this is for average conditions only: the acceleration can certainly be much higher. One must consider also the possibility that locomotion involves also protonic currents in which ATP is not produced.

Possible mechanisms of momentum, angular momentum, and energy transfer

One could try to understand the function of ATP by assuming that the usage of ATP involves generation of a photon with the energy .5 eV giving momentum to a motor molecule such as myosin or actin. The amount of momentum transferred to a motor molecule is $p = .5 \text{ eV}/c$. The corresponding velocity $v = p/M \sim 10^{-14}c$ is of order one $\mu\text{m}/\text{sec}$ and of the same order of magnitude as the velocities of the motor molecules like myosin and kinesin having masses $M \sim 10^5 m_p$. Therefore it seems that photon with energy $E = .5 \text{ eV}$ could indeed mediate the momentum to the motor molecules in the presence of ATP complex. The importance of this observation is that molecular motors could be genuine quantum motors moving without momentum dissipation and obviously at non-atomic space-time sheets where dissipation is indeed practically absent.

This observation leaves a lot of freedom to imagine various mechanisms.

1. Energy is stored as the zero point kinetic energy of ions and atoms at the atomic space-time sheets: this energy would be liberated when an ion or atom drops on a super-conducting space-time sheet. The photon carrying the energy .5 eV would also carry corresponding momentum. If the user sends a negative energy photon to the energy storage in precisely defined direction, the momentum is indeed generated in a coherent manner. The transfer of a beam circularly polarized photons along ME in the direction of rotation axis would generate torque in the direction of ME. If photons have large value of \hbar the unit of angular momentum would be large and large value of standard angular momentum currency would become possible. MEs are not however the best possible solution energetically. The target with mass m would receive the kinetic energy $\Delta E = E^2/2mc^2 < E$ and momentum $E = E/c$ so that most of energy would go to the internal degrees of freedom. Somehow the energy dissipation should be avoided and the seesaw mechanism to be discussed later could allow this.
2. There is a second manner to avoid energy dissipation and to avoid much larger momentum transfer. The mechanism is based on the induction of flux tubes making possible the flow of say electrons from the space-time sheet of the target to a larger space-time sheet generating the motion as a recoil effect. Also a phase transition of (say) electrons to their dark variants involves leakage to different page of the book like structure representing generalized embedding space and would lead to similar recoil effect. There is experimental support for this kind of mechanism. This mechanism would differ from the first in that the energy of photon would go to energy of the receiver and the leakage of the particles would give rise to much larger momentum transfer $\Delta p = \sqrt{2mE}$. For instance, the system moving could send negative energy photon to the energy storage (say "many-sheeted laser") and the constraint forces would force the resulting momentum to be given by the previous formula. The moving system would act like rocket.

Modanese and Podkletnov [H16] discovered that dielectric breakdown of a capacitor made of super-conducting and non-super-conducting electrodes induces unknown radiation inducing an oscillatory motion of penduli at large distances and that the effect does not weaken with distance as would happen if the penduli absorb the radiation. It was also found that absorption hypothesis would required the quanta of the radiation to be tachyonic. The explanation in terms of the proposed mechanism [K131] would mean that the MEs generated in dielectric breakdown would act as switches inducing the flux tubes needed for the leakage

of matter to larger space-time sheets and making the target to behave like rocket using its own fuel.

It turns out that in the case of molecular motors this mechanism implies too high momentum transfers whereas the first mechanism predicts correct order of magnitude.

3. Parallel supra currents of massive charge particles at magnetic flux tubes as carriers of momentum are more promising energetically since the momentum to energy ratio behaves as $\sqrt{2m/E}$ for them and the transfer of energy to internal degrees of freedom of the target would be much smaller. The supra currents associated with Bose-Einstein condensate of ions moving with constant velocity and possessing constant value of angular momentum in the direction of magnetic flux tube could make possible angular momentum transfer. This would require a mechanism transferring the momentum and angular momentum from the sender to the beam.

Constraints on the model for a coherent momentum transfer

Consider now the constraints on the model of the coherent momentum transfer.

1. The coherence of the momentum transfer results if the protonic current results from a leakage of the protonic supra-current to the atomic space-time sheet and is induced by the generation of flux tubes acting as Josephson junctions between magnetic flux tubes and atomic space-time sheets. The TGD based model for auroras [K24] suggests that this process is quite generally the mechanism destroying super-conductivity locally. A priori the magnetic flux tubes involved could correspond to the magnetic circuitry associated with the body or to much larger magnetic flux tube structure. This option does *not* require that the momentum of the ions of the protonic supra current is stored: the mere control of the process from this level is enough to guarantee coherence.
2. The extreme synchrony and coherence of the biological locomotion would be made possible by the fact that magnetic flux tubes and hence also electronic and protonic supra currents entering to the organism/organ/organelle/macro-molecule are parallel and are in the same phase. This allows simultaneous generation of the supra current leakage induced by the nerve pulse pattern in case of muscle cells. Since protonic supra currents have parallel momenta ATP molecules can transfer parallel momentum increment to about billion ATP molecules in billions of cells.
3. Magnetic flux tube structures with sizes of body seem to be enough to guarantee the coherence of the locomotion. The time scale of 1/200 seconds for the duration of single ADP-ATP-ADP process is of the same order of magnitude as protonic cyclotron frequency $f_c = 300$ Hz. If magnetic mirrors are involved also now, the wave length associated with the protonic cyclotron frequency 300 Hz in Earth's magnetic field suggests itself as the length of the magnetic flux tubes carrying the hydrogen ions and would thus be of order $L_p = 2\pi R/30$, where R is Earth's radius. The generation of the electronic charge attracting the protonic charge to the region between membranes is essential part of the process and now the leakage of the electronic supra currents to atomic space-time sheets should be involved. In case of electrons the lengths of MEs, if given by the wave lengths associated with the electronic cyclotron frequency, would be of order $L_e = 10^{-3}L_p/2 \sim 1.5$ km and corresponds to a time scale of 1.7 micro-seconds.

To sum up, if the proposed view has some seed of truth in it, super-conductivity in body length scale would be a central element of the functioning of organisms. Super-conductivity even in geophysical length scales could be crucial, not only for the realization of the sensory representations and motor actions, but also for the basic metabolic processes of life and for the coherent motion of living matter.

The phase transitions changing Planck constant as a basic mechanism

The phase transitions changing Planck constant induce change of the length of magnetic flux tube and this mechanism could serve, not only as the basic mechanism of bio-catalysis, but also as

mechanism generating gel phase phase transitions typically inducing a change of the volume of the cytoplasm. These phase transitions could be one mechanism involved with locomotion. Also the reconnection of flux tubes making possible to modify the hardware of topological quantum computer defining also TQC program, is an attractive mechanism inducing this kind of phase transitions.

1. Quantum criticality suggests that the phase transitions for the gel phase are induced by quantum phase transitions changing the value of Planck constant for magnetic flux tubes and inducing the change of the length of the flux tube. Macroscopic quantum coherence would explain the observed co-operativity aspect of the phase transitions. Concerning locomotion and transport mountain climbing using pickaxe and rope inspires a guess for a general mechanism. For instance, a packet of molecules moving along actin molecule or a molecule carrying a cargo along micro-tubule could repeat a simple basic step in which a magnetic flux tube with large \hbar is shot along the direction of the electric field along micro-tubule and stuck to a ratchet followed by a phase transition reducing the value of \hbar and shortening the flux tube and forcing the cargo to move forward. The metabolic energy might be provided by the micro-tubule rather than molecular motor.
2. The reconnection of flux tubes would be a second phase transition of this kind. This phase transition could lead from a phase in phase proteins are unfolded with flux tubes connecting amino-acids to water molecules and thus possessing a large volume of layered water around them to a phase in which they become folded and flux tubes connect amino-acids to each other in the interior of protein. The phase transition could be associated with the contraction of connecting filaments of muscle cell. The phase transitions are also seen in “artificial protein” gels used for drug delivery applications, and are built from polymers arranged in alpha helices, beta sheets and common protein motifs [I125]. If wormhole magnetic flux are taken are taken as a basic prerequisite of life, one must ask whether these “artificial proteins” represent artificial life.

9.5.2 Some Facts About Molecular And Cellular Motors

Molecular motors are enzymes having typical size about 10 nm and mass about $10^5 m_p$ moving along DNA strand, micro-tubules, actin filaments, through cell membranes, etc. Of course, the terms “motor” and “machine” must be taken with a big grain of salt in TGD Universe, where bio-molecules are conscious and intelligent selves and more like molecular counterparts of ants rather than dead nanoscale robots.

During the last years it has become possible to monitor the activities of a single molecule by using laser traps and optical tweezers: also the the responses of the molecules to external forces can be studied routinely [I111]. With the advance of the experimental techniques molecular motors have become a hot research topic during last years [I67, ?, I100].

Molecular motors transform chemical energy with the mediation of ATP molecules to mechanical work, transport work, energy of electromagnetic fields, and various types of chemical work.

1. The functioning of the skeletal muscle is based on the sliding of the myosin molecules along actin filaments. Kinesin molecules are two-headed molecules moving along micro-tubuli and carrying molecular cargo.
2. Molecular motors can transport molecules along DNA, transport various molecules such as neurotransmitters through the cell membrane or along axon. There is a vast kit of motors enzymes affecting the topology of DNA: for instance, these enzymes can zip or unzip DNA double strand, past, unwind, translate, replicate, unknot and repair DNA.
3. There is evidence that ionic channels are transformed to ionic pumps by a mediation of single ATP molecule [I68] . In light of the experiments challenging the notions of ionic pumps and channels, one is forced to ask what is really occurring in this process and what its real function is. In TGD framework ATP molecules is a plug connecting two magnetic flux tubes and $ATP \rightarrow ADP + P_i$ would induce shortcut of this flux tube. This flux tube could effectively act as ionic channel.

4. Molecular motors transform chemical work to various other forms of chemical work. Consider only the assembly and breakdown of proteins and DNA replication as examples.
5. The machines producing the energy needed by the other machines are obviously exceptional and thus especially interesting. The generation of ATP, usually believed to serve as a universal energy currency (this view is challenged by TGD approach), involves a protein machine known as $F_0 - F_1$ machine [?, ?].

Consider now general features of these machines.

1. A common denominator of all these activities (the F_0 machine producing ATP molecules forms an obvious exception) is that ATP complexes somehow provide the energy needed by the process and this energy is quantized. The time scales involved are very long, for instance 1/100 seconds for a single step of the kinesin along the micro-tubule or 1/20 seconds for the addition of a single amino-acid to a protein in the translation of mRNA. These time scales represent almost an eternity as compared to the time scale of the dissipative effects: for instance, for a protein in water the time scale τ defined by the frictional force $F_d = mv/\tau$ is of order $\tau \sim 10^{-13}$ seconds [I111].
2. If space-time is single-sheeted, the macroscopic time scales for these processes imply that classical mechanics based description relying on conservative force fields combined with Brownian and dissipative forces should be an excellent approximation. The chemical aspects of these processes should in turn be modellable by statistical models relying on thermal arguments. In the many-sheeted space-time and for a hierarchy of Planck constants the situation need not be this since molecular motors could move along cold space-time sheets and the constant velocity for this motion could be erratically interpreted as resulting from frictional forces.
3. Also definitely quantal aspects are present. The motion of the molecular motors is quantized to steps. For instance, the motion of the kinesin along micro-tubule is quantized with the length of single step being 8 nm. Kinesin uses always the same energy of about .5 eV provided by single ATP complex [I58]. Since the energy needed to perform a single step in the process is quite generally provided by the ATP complex and thus constant and independent on the properties of the fluid (viscosity, ionic concentrations, ..) which can be varied, one must conclude that the energy given by ATP complex is considerably larger than the energy needed by the process. The energy could be however used to kicking the molecule from the local potential well. Rather intriguingly, if kinesin molecule receives momentum of photon with energy of .5 eV, it gets velocity which is of correct order of magnitude. Thus quantum motor option might work!
4. Thermal ratchets for which the ATP molecule induces local heating with heat energy being rectified to directed kinetic energy, predict deterministic motion. The motion of a myosin molecule along the actin filament the motion is however effectively non-deterministic consisting of one to five steps and sometimes occurs also backwards but that always single ATP molecule is used [I114]. The average number of steps is three and the length of single step is 5.3 nm.

9.5.3 Molecular Motors In Single-Sheeted Space-Time

The experimental advances have generated vigorous theoretical activity involved with molecular motors. The basic challenge is to understand how the molecular motors are able to fight against the thermal motion.

To get some idea about the challenge provided by the thermal noise, it is good to have some order of magnitude view about the forces involved. A typical protein has mass $m \sim 10^6$ proton masses. In water it experiences friction force $F_d = mv/\tau$, $\tau = 10^{-13}$ seconds. The Brownian force experienced by protein, say kinesin, is of the order of magnitude

$$f_B \sim mv_T/\tau \quad ,$$

where $v_T \sim \sqrt{kT/m}$ is the thermal velocity. The resulting typical Brownian force is of order one nN (nanoNewton). Let us compare this random force to the force associated with organized motion.

Kinesin moves a distance $L = 8$ nm along micro-tubule during .01 seconds by using an energy of about $\Delta E = .5$ eV provided by a single ATP molecule. The average force is $F = \Delta E/L \sim 10^{-2}$ nN and by two orders of magnitude weaker than the typical Brownian force. This is like driving car pushed and pulled by random forces varying their direction in a time scale of 10^{-11} seconds and which are of same order of magnitude that the force usually needed to give the car a velocity of order 100 m/s!

From this estimate it is clear that the theoretical understanding of how molecular motors can cope with the thermal noise cannot be achieved by a routine application of the existing methodology. Something more is needed. The attempts to meet the theoretical challenge are based on the notion of ratchet rectifying thermal energy to a coherent motion. One school believes that various classical ratchets, which are actually more or less must in a single-sheeted space-time, are enough to explain everything. There are also those who believe that quantum ratchets might be needed but here the needed extremely low temperatures are the stumbling block in a single-sheeted space-time. The notion of many-sheeted space-time however suggests a simple solution to this problem: put all moving parts of a quantum motor to the cold space-time sheets.

Brownian ratchets

The standard thermodynamical approach is based on free energy diagrams telling only what is impossible. One can go however further and try to build models for the molecular motors. Hard-boiled reductionism, together with the observation that the relevant time scales are measured using a fraction of second as a natural unit, implies that molecular motors must be purely Newtonian mechanical motors using chemical energy. The basic challenge is to understand how these motors are able to fight against or rather, utilize, thermal motion which in the molecular length scales is dominating in the framework of standard quantum theory.

1. Basic framework and questions

The premises above lead to the following picture.

1. Molecules obey Newtonian mechanics and quantum effects manifest themselves only statistically and are buried in the parameters characterizing effective model (such as effective chemical kinetics). Besides conservative forces used to describe the interaction of the motor with the medium and the presence of the load, there is friction and randomly fluctuating forces characterizing the Brownian motion caused by the thermal effects. Fluctuation-dissipation theorem is used to relate dissipation constant to friction.
2. Basic question is how chemical energy is transformed to mechanical energy.
3. The questions related to how the motors are controlled and how macroscopic synchronous motion is achieved are not pondered in this approach, to say nothing about the possibility of macroscopic quantum states.

2. The notion of ratchet

The basic challenge is to understand how the thermal perturbations in the molecular length scales, which are of the same order of magnitude or even stronger than the amplitude of the ordered motion, can be tamed, circumvented, or utilized. The ingenious idea is the notion of Brownian motor rectifying Brownian motion (for material about Brownian motors see [I67, ?, I100]).

Ratchet is essentially a rectifier that picks up the component of motion that is in the desired direction. The asymmetric periodic saw tooth like structure characterizes ratchet. Screw-driver and the transformation of the motion of the clock pendulum to the motion of the hands of the clock rely on the ratchet principle.

One might naïvely think that thermal perturbations of a ratchet could be quite generally rectified and thus generate a macroscopic motion. This would obviously mean failure of the second law of thermodynamics and perpetual mobile of the second kind. This is not possible as shown for the first time by Smoluchowsky in 1912 and also demonstrated by Feynman later in his Lectures in Physics. The situation however changes in case of far from thermal equilibrium systems.

One can invent myriads of ratchets once a sufficiently abstract definition of a ratchet is available. The asymmetric periodic structure of the cogwheel is abstracted to a potential which is periodic such that the potential well has the characteristic asymmetric shape.

1. In case of a thermal ratchet periodic heating (which requires energy so that one cannot circumvent the second law) causes the motion in case that the average distance diffused by a particle during the higher temperature period is shorter than the width of the asymmetric sawtooth like potential well. During the low temperature period particle ends up to the right, deeper end of the potential well. If the particle diffuses to the left during high temperature phase, it remains in the original potential well. If it diffuses to the right, it ends up to the next well before next heating. Thus there is a net motion to the right.
2. Also the ratchet potential might vary with time (note that this requires energy feed to the system so that the second law is respected also now). In an idealized situation potential varies from asymmetric saw tooth to constant potential and back. During the period of constant potential particle diffuses freely and if the length traveled in this manner is shorter than the width of the potential well, particle moves to the right.
3. Also oscillatory electromagnetic field containing higher harmonics of the fundamental frequency and coupled to a Brownian motor in a non-linear manner can induce the rectification of Brownian motion.

The ratchet mechanism is so general that one can invent practically endless number of Brownian motors. The basic signature of the ratchet mechanism is extremely loose coupling between the asymmetric periodicity of the potential function and the presence of a time varying external perturbation. This loose coupling is what makes the mechanism so rigid and universal and also testable. In fact, the experiments of Steven Block about the motion of kinesin along micro-tubule suggest that the coupling is *not* loose [I58].

In the case of molecular motors chemical energy liberated with the mediation of ATP molecule is the basic driving force. For a thermal ratchet the liberated chemical binding energy would induce local heating of the system and this in turn would lead to the ordered motion of the motor enzyme. One can imagine that also the ratchet potential, say the asymmetric periodic potential along micro-tubule or actin filament, could be modified by the chemical energy liberated by ATP molecule.

4. Mathematical modelling of Brownian motors

Material about the mathematical modelling of Brownian motors can be found [I67, ?, I100].

1. Newton's equations are used to model the motion of the motor molecule. The interaction with the medium in which molecule moves is characterized with an asymmetric periodic potential function. The load (second molecule carried by the molecule) is described by an additional term in potential function giving rise to constant opposing force. Friction is characterized typically by a force proportional to the velocity of motion and thermal perturbations are described by a randomly fluctuating force. In equilibrium situation in which the average acceleration of the particle vanishes, particle drifts with an average velocity proportional to the net force. Fluctuation-dissipation theorem relates friction coefficient to the diffusion constant D characterizing the Brownian motion and to temperature.
2. Probabilistic description using time dependent probability distribution for the position of the particle is used for practical purposes. The basic equation states the probability for a given chemical compound to exist in a given infinitesimal volume element is affected by diffusion, by the flow caused by the drift force and by chemical reactions.
3. Chemical reactions, typically binding of ATP or some other energy carrier molecule and its hydrolysis, are modelled in a very rough manner in terms of effective reaction kinetics using effective rate constants. Thermodynamical arguments based on Gibbs free energy are central. The increment of Gibbs free energy $\Delta G = \Delta H - \Delta(TS)$, which determines to which direction the reaction proceeds and the ratio of the initial and final state concentrations in equilibrium situation. In constant temperature the increment ΔH of the enthalpy representing

typically change of the electrostatic energy and $T\Delta S$ term representing entropy increment are competing factors.

4. In biological systems water is a crucial participant: before a charged ion can bind to, say amino-acid, both reactants must get rid of the waters of hydration surrounding them. Binding itself reduces entropy in the translational degrees of freedom whereas the liberation of molecules from hydration waters increases the entropy and more than compensates the reduction of entropy. Obviously the situation in question is very complex and only rough phenomenological parameterizations are possible.

In TGD view about functioning of ATP the coupling to water is especially non-trivial: ATP does *not* serve as energy currency but acts as a catalyst making possible to transform the zero point kinetic energy of proton of the hydration waters to a usable energy.

5. Criticism

One can criticize the approach for several reasons.

1. The use of the potential to describe the force is quite a strong idealization and breaks momentum conservation. A more explicit manner to model also the momentum economy would be highly desirable but not possible in the simple Newtonian framework.
2. Biological systems are extremely ordered and purposefully behaving systems: consider only the translation of DNA to proteins as an example. Their modelling using the approach originally developed for the description of dead matter, seems highly questionable.
3. The models for the molecular motors do not discuss control aspects at all. The actual presence of meso- and macroscopic coherence making possible macroscopic organized motion is neglected completely in the reductionistic approach in which everything is assumed to allow modelling at atomic and molecular physics level and believed to reduce to effective theories. In TGD framework these aspects are sides of the same coin and neglecting the presence of correlations in mesoscopic and macroscopic length scales might mean the neglect of something absolutely essential. Of course, it might be that with good luck the model for the motion of the motor enzyme along micro-tubule might be separated completely from its control but this is by no means obvious.
4. There exists empirical evidence against the notion of the thermal ratchet. Thermal ratchet seems to be the most realistic approach for the modelling of the motion of motor enzymes along micro-tubule and actin filament [?]. In this model the energy liberated in the binding of the ATP molecule is used to increase the local temperature in turn allowing the particle to diffuse along the asymmetric and periodic ratchet potential. The basic qualitative predictions are that the motion occurs only single step at time and deterministically, and that the energy needed to carry out single step should depend on the state of the liquid unless the energy liberated with the mediation of ATP molecule is much higher than the energy needed.

However, the motion of the myosin along the actin filament involves one to five steps and can occur sometimes also backwards [I114]. This is not easy to understand if thermal ratchet is in question. The non-determinism can be understood classically as an apparent non-determinism if ATP gives also coherent momentum to the myosin (say via radiation pressure) and if the direction of momentum depends on the relative orientation of the ATP molecule and actin filament. The more radical option is that a genuine quantum motor is in question: in this case the motion would continue until it is stopped.

In the case of kinesin the energy liberated by single ATP molecule gives always rise to a single step of motion and the energy used per step does not depend on the state of the fluid [I58]. This can be understood if the energy liberated by the ATP complex is much higher than the actual energy needed: this seems indeed to be the case. According to [?] the thermal ratchet fails also at quantitative level being unable to explain the speed of the motion.

Quantum ratchets

Classical ratchets rectify the Brownian motion. A simplest quantum variant of classical ratchet studied by Hänggi and Reimann [1133] is a spatially periodic lopsided potential in which electrons move. If one modulates this potential periodically, the electrons move inside the lopsided wells to either direction and this also modifies the shape of the wells. When the potential well is lowered, highest energy electrons can spill to the well on the right and are localized to the bottom of the well as potential well gets deeper. Thus one can make electrons to move up-hill.

Genuine quantum ratchets are however much weirder. They rectify quantum fluctuations and rely on quantum tunnelling. Also now the motion occurs in a ratchet potential with the characteristic asymmetric periodic structure and modulated by oscillating potential difference between the sequence of lopsided potential wells. Now however temperature is very low and the tunnelling of the electron is what leads from potential well to another one. Since tunnelling probability decreases rapidly when the tunnelling length increases, the tunnelling should occur when the well is deeper and electrons are at the left hand side of the well. Thus the electron current should flow to the left rather than right in this case.

Heiner Linke tested experimentally this effect by constructing a string of triangular shaped quantum dots [198]. Linke saw the predicted effect but at much lower temperatures the direction of the current became very sensitive to the strength the potential signal and effect became essentially unpredictable. The explanation is in terms of interference of electron waves. The occurrence of the tunnelling requires also that there is something which can tunnel. Thus a destructive interference can inhibit the tunnelling which could occur otherwise. Thus interference effects obviously provide an optimal control mechanism and the possibility of wireless electronic circuits has been suggested as a possible technological application. In TGD framework the interference effects caused by MEs provide a very attractive control mechanism of supra currents.

9.5.4 Molecular Machines In TGD Framework

Steven Block, one of the top researchers in the field of the molecular motors, summarizes the recent theoretical situation by saying “Everything you know about biophysics... is wrong!”. Thus there seems to be some room for new physics and chemistry. TGD indeed brings in several new elements: the notion of many-sheeted ionic flow equilibrium and quantum control based on MEs and supra currents; hierarchy of Planck constants; buy now-pay later mechanism based on the generation of bound states and allowing effective over-unity energy production accompanied by automatic generation of meso- and even macroscopic quantum coherence; and finally but very importantly, the molecular motion along dark and non-atomic space-time sheets in principle allowing to dramatically reduce dissipative effects. Note that the second law is respected since (very!) far from thermal equilibrium systems are in question.

Questions

TGD approach stimulates several critical questions about the fundamental notions involved with the motor enzymes. The first group questions relate to the basic philosophy and fundamental working principles of molecular motors.

1. Is the highly mechanistic notion of the molecular motor really appropriate in TGD framework or should one regard motor enzymes as tiny but conscious and intelligent creatures forming a society able to co-operate and solve problems. In the following the notion of molecular motor is used but without the usual robotic coloring. Equally well one might call a highly specialized professional a robot.
2. How the living matter manages to cope with the thermal motion? Could molecular motors be able to minimize friction by using \hbar increasing phase transitions.
3. How the quantum control is realized? How many-sheeted ionic flow equilibrium is involved with the control of the motion: in particular, how it determines the direction of the movement of a molecular motor around DNA strand, micro-tubule, or actin filament? Could it be that the direction of the supra current breaks the symmetry and fixes the direction of the motion? What is the role of Ohmic currents on atomic space-time sheets?

Second group of questions relates to the energy economy.

1. Is ATP indeed the universal energy currency or does it only connect the user of energy to its provider? The notion of high energy phosphate bond is indeed unconvincing and suggests that the understanding of ATP is far from complete. Is the ATP related energy source the only energy source or could the generation of macroscopic bound state entanglement make possible effective over unity energy production as suggested by the strange findings about neuronal metabolism [J97] ?
2. No consensus exists about how the chemical energy is transformed to mechanical energy or other forms of chemical energy. Is the energy per single step of a molecular motor always the same and provided by the ATP complex as in the case of the kinesin motion? What does the independence of the energy used per single step on the state of the cellular water mean and why the variation in the rate of dissipation does not change the amount of the energy needed? How so high an efficiency is possible in extremely dissipative circumstances: molecular motors have a better efficiency than ordinary motors although the situation should be just the opposite. In particular, $F_0 - F_1$ motor generating ATP molecules has essentially unit thermal and Stokes efficiencies [?].
3. ATP complex should liberate energy used to perform chemical work as single quantum. If molecular motors behave classically the energy should be liberated in very small increments in order that the process is reliable and controllable. Could one think the possibility that chemical machines operate quantally whereas molecular motors are effectively classical machines? Or are both quantum and classical modes possible for molecular motors?

The third group of questions relates to the properties cell membrane.

1. What this the real function of the ionic channels and pumps? There is evidence both supporting [I68] and challenging these notions [I125] and somehow one might hope that the notion of many-sheeted space-time could resolve this apparent paradox. In [K96] the TGD inspired solution is discussed in detail.
2. What is the real function of the cell membrane resting potential? What is the real role of the ionic currents associated with nerve pulse activity? How the ionic currents generate EEG waves? The facts that resting potential is -63 mV and the zero point kinetic energy of proton Cooper pair at $k = 139$ super-conducting space-time sheet is 61.5 meV suggests that the real function of the resting potential is to prevent the leakage of the protonic Cooper pairs from $k = 139$ space-time sheets to the super-conducting space-time sheet.

Many-sheeted molecular machines

The TGD based solution to the problem of coping with the thermal noise is simple: increase the value of Planck constant. This means essentially zooming up of the quantal scales to longer ones, even macroscopic. There are however several options whose realism can be judged by using simple order of magnitude estimates. Basically one must choose between whether momentum or energy is used as a fuel. If momentum of exchanged photons is used as a fuel, one must invent a mechanism to avoid large dissipation of energy. If energy is used as a non-dissipative fuel the problem is how to avoid too large momentum transfer and this seems to require large friction forces.

1. Mountain climber mechanism

A rather plausible sounding option is based on the mountain climber mechanism in which the motor action of magnetic body induces the motion of molecule. The moving system induces an \hbar increasing phase transition of flux tube. The flux tube attaches to the substrate along which the molecule is moving and after this a phase transition reducing the value of Planck constant and forcing the molecule to move takes place. The attachment of the rope could mean attachment of ATP molecule appearing as a plug in flux tube to F_1 and subsequent $ATP \rightarrow ADP + P_i$ cutting the flux tube. The energy would come from dropping of three protons to a larger space-time sheet and the direction of motion would be dictated by the direction of the flux tube along the linear structure. This direction could be statistically determined for single step but there would be a

preferred direction determined most naturally by the electric field along the linear structure. The momentum gained by the moving system would be dictated by the proposed rocket mechanism and there would the dissipation of energy would be minimal.

2. Seesaw mechanism

Assume that the molecule gets the momentum $p = \Delta E/c = .5 \text{ eV}/c$ from ATP. In this case the velocity of the molecule is $v = p/M$ and for $M \sim 10^5 m_p$ the velocity is of order $\mu\text{m}/\text{sec}$ which is of correct order of magnitude! Thus motor molecules could also act as quantum motors and their constant velocity would reflect the absence of dissipation rather than presence of it!

The velocity of the quantum motor is fixed completely to $v = p/M$ for this option. This is obviously very strong prediction and makes it easy to kill the model. The second testable prediction is that the ratio for the velocities of two quantum motor molecules is given by the inverse of the mass ratio.

Large dissipation can be avoided by using seesaw mechanism. The ADP molecule in the moving system sends negative energy photon transferring a proton in energy storage system to a larger space-time sheet and induces $ATP \rightarrow ADP + P_i$, and then energy storage system sends the negative energy photon back to the moving system inducing $ATP \rightarrow ADP + P_i$. At each step the moving system receives momentum $p = E/c$ but its net energy does not increase. This process could correspond to $ATP \rightarrow ADP \rightarrow ATP \dots$ for both systems involved. Obviously this mechanism can be combined with the mountain climber mechanism.

The seesaw mechanism applies in the case of quantum rotor. In the ideal case the angular momentum is not dissipated and only an exchange of few negative energy photons between ATP: s and polarized in the direction of the rotation axis is enough to gain the needed angular momentum. In the presence of dissipation continual exchange is required. The rotation of the shaft of F_1 machine could be due to this mechanism.

4. Quantum motor mode is required to perform chemical work

ATP complex is involved also with the performance of chemical work. In this case the zero point kinetic energy of the proton *must* be liberated as a single quantum (this actually supports the view that molecular motors indeed act also in quantum mode). Thus ATP complex must act both in effectively classical and genuinely quantal manner. Enzymes are the most important molecular machines and their poorly understood action could involve the notion of many-sheeted space-time in an essential manner. For instance, ions could avoid Coulomb walls by approaching other reactants at atomic space-time sheets along larger space-time sheets. Perhaps even chemical reactions could occur at cold space-time sheets: this would mean that the dropping of the chemicals to cold space-time sheets rather than heat could excite intermediate states.

4. Could classical motor run with the energy provided by ATP complex?

Assume that the energy .5 eV goes to the kinetic energy of the motor molecule rather than to the environment of the molecule. The average velocity of a typical motor molecule like kinesin during single step is $v = s/t$, where $s \sim 10 \text{ nm}$ the length of single step and $t \sim 10^{-2} \text{ sec}$ the duration of single step. The movement with dissipation requires energy feed

$$\Delta E_d = F_d s = \frac{mvL}{\tau} = 2E_{nd} \frac{t}{\tau} ,$$

where $\tau \sim 10^{-13} \text{ sec}$ characterizes time scale of friction and E_{nd} is the energy needed in the absence of dissipation. This energy is by a factor $t/\tau \sim 10^{11}$ larger than the energy when the movement occurs without friction. Thus quantum motor option does not make sense if motor molecule receives the entire energy .5 eV from ATP complex.

New view about $F_0 - F_1$ machine

$F_0 - F_1$ is in certain sense a universal machine. It acts as a ionic channel for protons and in the reverse mode as a protonic pump. It generates also ATP and in reverse mode uses it. Besides this $F_0 - F_1$ acts as a rotary motor. The model for $F_0 - F_1$ machine allows to resolve the paradoxical situation raised by the experiments challenging the notions of ionic pumps and channels [K24].

$F_0 - F_1$ motor is certainly an extremely complex structure [?, ?] and I confess of being deeply ignorant of its intricate chemistry and functioning. Despite this I cannot avoid the temptation to understand the basic purpose and working principles of this machine. My only excuse is that this kind of exercise could promote the understanding of the basic principles of the many-sheeted molecular engineering.

1. $F_0 - F_1$ machine as ATP synthesizer

As mentioned the machine producing ATP is different from other machines since it cannot use ATP as an energy currency (except in the reverse model!). This machine works somewhat like a hydro-electric generator or actually pair of them turning the shaft to opposite directions [I3, ?, ?, I111]. The proton flow induced by F_0 subunit rotates the shaft and this induces the stator like subunit F_1 to synthesize ATP whereas ATP hydrolysis in F_1 causes a reverse rotation of the shaft and reverses the flow of protons.

Protons are accelerated in an electric field generated by electrons and, according to the standard view, the machine transforms the energy produced by the oxidative metabolism to the energy of the high energy phosphate bonds of the ATP molecule. TGD view however suggests that ATP molecule does not carry energy but acts as a switch allowing the liberation of energy when protons drop from atomic space-time sheet the super-conducting space-time sheets. Thus F_0 machine would generate usable energy by kicking up protons to the atomic space-time sheet.

2. $F_0 - F_1$ machine as a rotary machine

$F_0 - F_1$ acts also as rotary motor rotating the so called γ shaft [?, ?] and thus transferring the momentum of the supra currents at super-conducting space-time sheets. The accelerated super-conducting protons flowing through the space-time bridges through the region defined by the inner membrane of the mitochondria obviously provide momentum rotating the shaft. There are reasons to believe that this mechanism is very general and behind various rotary machines in the living matter. The beauty of this mechanism is that the generation of coherent momentum becomes possible since supra currents form a coherent macroscopic quantum systems.

3. Does the coupling $F_0 - F_1$ machine to actin filament make it classical machine

$F_0 - F_1$ machine can work also in reverse direction and a lot has been learned about the functioning of this machine. In this mode the machine becomes a proton pump. By attaching an actin filament to the shaft of the machine it has been found that both the thermal efficiency and so called “Stokes efficiency” are very near to one for F_1 motor acting as proton pump [?]. According to the analysis of [?] this implies that the torque generated by the binding of ATP molecule to the catalyst and the liberation of the phosphate group cannot liberate the Gibbs free energy instantaneously but with a constant rate. This argument is based on a simple model of F_1 pump with the friction losses caused by the actin filament attached to the shaft modeled as a linear friction. This result is obviously a theoretical challenge.

1. If the protons provide their energy instantaneously, the hydrodynamic efficiency becomes effectively zero: ΔG is concentrated to a single moment of time and the angle of the shafts changes instantaneously by angle $\Delta\theta = 2\pi/3$. According to the formula of [?] this would give vanishing rather than maximal “Stokes efficiency”. Or putting it otherwise: the torque would be instantaneous rather than constant as also direct experimental data suggest.

There is however an important caveat involved here: constant torque corresponds experimentally to a constant rotation velocity and constant rotation velocity characterizes also non-dissipative quantum motion. The classical rotation velocity $\omega = L/I$ (I denotes the moment of inertia and $L = \hbar$ angular momentum) is indeed of correct order of magnitude $10^2/s$ for $I \sim MR^2$, $M \sim 10^7 m_p$ and $R \sim 10$ nm.

2. That Stokes efficiency equal to unity came as a surprise in the standard chemical model where one also expected that the Gibbs free energy is liberated essentially instantaneously. The explanation for the phenomenon proposed in [?] is based on the tight coupling between mechanical and chemical degrees of freedom (should be loose for Brownian machines in general) predicting nearly unit thermal efficiency and a continual liberation of the Gibbs

energy with a constant rate. The latter was assumed to be due to a gradual generation of the Gibbs free energies associated with the hydrogen bonds binding ATP to the catalyst site. In case of phosphate molecule one must assume that the energy liberated when the phosphate molecule is released from $F_1 \cdot ATP \cdot P_i$ complex remains to $F_1 \cdot ATP$ and is liberated at constant rate. Mechanism would be similar to that in case of ATP. One can criticize this view: the time scale of 1/200 seconds for the buildup of hydrogen bonds instead of the time scale of 10^{-13} seconds suggested by Uncertainty Principle looks unrealistic.

As found, in TGD framework the problem disappears since molecular motors would be almost dissipation free quantum machines.

Examples of many-sheeted molecular motors

TGD by no means excludes the thermal ratchet model but suggests the radiation pressure based classical motor and quantum motor options as a more plausible alternatives. Myosin moving along an actin filament and kinesin moving along a micro-tubule provide two basic examples of molecular motors and they could serve as a testing ground selecting between these models. Rather remarkably, quantum option predicts correctly orders of magnitude for the velocities of the molecules. Perhaps both quantum and classical modes are possible and which mode is chosen depends on whether the molecule moves along atomic space-time sheet or larger space-time sheet.

1. The motion of a myosin molecule along actin filament

The motion of the myosin molecule along actin filament involves one to five steps each of length about 5.3 nm (this length scale is somewhat longer than the p-adic length scale $L(149)$). This is not consistent with the thermal ratchet paradigm. As already found quantum motor option based on mountain climber mechanism and seesaw mechanism using $ATP \rightarrow ADP \rightarrow ATP...$ is most plausible in TGD framework. The following provides a simplified sketch about how the motion could take place.

1. Suppose for definiteness that the motion is to the right with “right” defined as the direction of electric field along actinin molecule. At each step flux tube containing ATP would be thrown like a rope along actinin filament to the right and get attached to it after which the myosin molecule would follow. This process would be essentially tunnelling between two potential energy wells. The direction of electric field along actinin molecule would select “right” as the more probable direction. This is to be expected if myosin molecule is charged.
2. At the first step ADP_1 attached with the myosin molecule would send negative energy to ATP_2 at left and get the recoil energy inducing $ADP_2 + P_i \rightarrow ATP_1$ allowing ATP_1 to attach with the flux tube to tunnel from the potential well and move to the right as a result of recoil momentum. This would induce the decay $ATP_2 \rightarrow ADP_2 + P_i$.
3. At the next step ADP_2 would complete itself to ATP_2 by sending negative energy and momentum to the ATP_1 and inducing $ADP_1 + P_i \rightarrow ATP_1$. At this step the myosin molecule itself should move to the next potential well to the right.

2. The motion of a kinesin molecule along micro-tubule

It is known that the motion of the kinesin molecule occurs in steps of total length of 8 nm and that single step lasts for 1/100 seconds. Kinesin molecule has two heads and the motion resembles the movement of a molecular Tarzan along a horizontal rope by alternately placing one hand over the other. According to [I99], head 2 leapfrogs over the firmly fixed head 1 a distance of 8+5 nm and begins to rock back and forth. Then ATP molecule liberates the energy causing head 1 to wobble un-controllably and head 2 proceeds additional 3 nm and is firmly fixed at the surface of the micro-tubule. Then head 1 repeats the same and each step means progress of 8 nm giving velocity of 800 nm per second which, by the way, is rather near to the velocity of slow Ca^{++} waves in astrocytes. The more ATP there is around, the harder it is to stop the motion of the kinesin [I58]. It is of some interest to notice that the numbers 3, 5, 8 and 13 are Fibonacci numbers appearing almost everywhere in living matter.

The mechanism should be a generalization of the mechanism discussed. The simplest idea would be that the heads exchange a negative energy metabolic quanta back and forth. This is however not quite enough: also a third ATP molecule outside the kinesin molecule is needed to perform the basic step. The necessary presence of ADP_3 explains why it is hard to stop the motion when ATP is present. One manner to fill in the details could be following.

1. ADP_2 at head 2 attached to the flux tube sends a negative energy photon to ATP_1 and transforms to ATP_2 molecule. Recoil momentum kicks ATP_2 attached at flux tube a distance $8 + 5$ nm to the right. The recoil energy received by ATP_2 puts it in rocking motion in local potential well. $ATP_1 \rightarrow ADP_1 + P_i$ in turn puts head 1 in wobbling motion.
2. ADP_3 to the left of kinesin molecule transforms to ATP_3 by sending a negative energy photon to ATP_2 inducing $ATP_2 \rightarrow ADP_2 + P_i$. The received momentum pushes it 3 nm to right and negative energy stops rocking motion and fixes head 2 to the surface of the microtubule.
3. Head 1 repeats the same process.
4. The velocity $v \sim \mu\text{m}/\text{sec}$ is predicted if the mass of the kinesin molecule is of order $10^5 m_p$.

A decisive test for the quantum motor option is to look whether the motion of the molecular motor could be induced by irradiating it with coherent light with photon energies around .5 eV. By the universality of the ATP mechanism irradiation at this frequency could have several kinds of effects on living matter.

Flagellar motors

Bacterial motors operate in much longer length scales than molecular motors and the principles might differ from those utilized by the latter. In particular, quantum motor mode might be impossible now. The motion of bacteria, say Escherichia Coli, is based on flagellar motors involving a rotating helical propeller. When the spin is in anticlockwise direction, flagella come together and the motion the motion propels the cell through the fluid. When the spin is in clockwise direction, the flagella fly apart and a tumbling motion results. The binding of a phosphorylated CheY protein to the portion of the motor located in cytoplasm induces promotes counterclockwise rotation by inducing a conformational change of flagella.

The friction between water and bacterium making impossible slipping makes possible the propelling motion. A rotating helical propeller induces in the general case a motion of the fluid. This motion is minimal when the helical propeller as an abstract surface remains locally stationary during the motion so that the energy dissipation is only due to the frictional losses implied by the fact that the fluid near the propeller must co-move with it. For a helical curve $z = a\phi$ describing idealized flagellum this means that the motion is a combination of a translational motion in the direction of the axis of the motor and rotational motion with rotation and thus of the form $z = vt, \phi = \omega t, v = a\omega$ implying that the motion is along the curve $z = a\phi$.

$F_0 - F_1$ motor in the reverse mode induces the rotation of $F_0 - F_1$ shaft in reverse direction and thus acts as a rotary motor. The functioning of flagellar motor might be based on the same principles as $F_0 - F_1$ motor.

A possible quantum mechanism generating the torque of quantum rotor is inspired by the work in attempts to understand the claimed strange effects in rotating magnetic systems [H18] in TGD framework [K12]. The mechanism might apply to both molecular and bacterial motors [I19].

1. Consider a molecular rotor attached to the cell membrane and having its rotation axis orthogonal to the cell membrane. Assume that there is a magnetic field along the axis of the rotating shaft and that the system can also generate a pulse of line charge along the axis of the shaft. The pulse of line charge creates a pulse of radial electric field inducing a Josephson current along radial flux tubes assumed to be present. The oscillating Josephson current continues as a DC current after the disappearance of the line charge. The lines of Lorentz force experienced by (possibly dark) charge carriers at flux tube rotate along the axis of shaft and the result is a torque in the direction of the axis of the shaft.

2. The control parameters are the amplitude and duration of the charge pulse. These parameters determine the sign and the magnitude of the DC Josephson current proportional to the factor $\sin(\int 2eV dt)$ but do not affect its maximum value. Using this kind of pulses the system can control the direction and magnitude of the torque.
3. The mechanism generating the line charge could be following. There is a strong electric field defined by membrane potential along the axis of the shaft and Josephson currents are running along the axis. The period of these currents depends on the magnitude of Planck constant for the flux tubes carrying the currents and the period can correspond even EEG time scale. The net charge density associated with the Josephson currents is expected to vanish. Suppose that the system is able to generate a resistance. The resistance experienced by various charge carriers are different so that the net effect would be a temporal generation of charge density on the axis creating the desired charge pulse. One can even consider effective cutting of the flux tubes at either side of the membrane so that charge begins to accumulate at the flux tubes.
4. In the model of DNA as topological quantum computer this kind of shortcut of flux tubes initiates topological quantum computation and the mechanism is the reconnection of the flux tube with the flux tube representing hydrogen bond between water molecules so that currents through flux tube goes effectively to ground. $ATP \rightarrow ADP + P_i$ would be the basic example of this kind of shortcut and should be involved also now. ATP can be regarded as a plug in flux tube connecting two molecules. The flux tube coming to adenosine aromatic ring from the first molecule continues via $O =$ atoms of phosphates to the target molecule. The shortcut splits the flux tube between second and third $O =$ atoms of ATP and induces $ATP \rightarrow ADP + P_i$. In the ideal situation this shortcut would be the only source of dissipation.

Transforming ionic channels to pumps

Just like the notion of high energy phosphate bond, also the concepts of ionic pumps and channels are both supported and challenged by empirical facts. As already explained, the paradoxes disappear in TGD framework. For supra currents running along super-conducting space-time sheets, no metabolic energy is needed to move through the cell membrane. Cell must however transport also ions from atomic space-time sheets to atomic or from atomic to super-conducting space-time sheet. In atomic-atomic case the intelligent solution is to drop the ions to the super-conducting space-time sheet and kick them back at the second side of the cell membrane (this might occur also spontaneously) if ions have enough energy. The ions indeed receive energy when they drop to the magnetic flux tubes from the atomic space-time sheets. The identification of the super-conducting space-time sheet would be as a magnetic flux tube having large value of Planck constant. ATP molecule would be attached to this flux tube and the splitting $ATP \rightarrow ADP + P_i$ would cut the flux tube and change ion channel to ion pump.

A test for this picture comes from a mechanism transforming channel to pump [168]. Channel is a funnel like channel protein with a tip at outer membrane and mouth opening to the cell interior. When the mouth is open to the inside of the cell, there is a strong interaction of ions with interior. When the mouth is closed, the ions in the channel are released to outside. ATP binding favors the opening of the mouth and the release of the hydrolysis products favors the closing of mouth (in other words, the decay $ATP \rightarrow ADP + P_i$ splits the flux tube). It is found that alternating electric field induces pumping even without ATP [168].

Previous considerations suggests that the two protons dropping in ATP binding opens the mouth and the proton dropping in the breaking of the phosphate bond closes it. One could also interpret the mouth as a system inhibiting the spontaneous flow of ions to the super-conducting space-time sheets. The fact that also single step of kinesin motion has a similar two-step structure encourages to generalize: perhaps all processes involving ATP could have this characteristic two step structure.

9.6 Miscellaneous

To make things easier to the reader, I summarize briefly the earlier ideas related to quantum control up to the crucial ideas related to the dark matter hierarchy. I also include a section about possible realization of four-wave mechanism under “attribute” miscellaneous since this mechanism makes rather strong assumptions and is probably not generic enough in its present form. I have still not been able to throw away a weird looking idea about connection between superluminality and remote metabolism. Reader can safely skip over this section at the first reading.

9.6.1 Older Ideas

Homeopathy in many-sheeted space-time and scaling laws

The attempt to understand homeopathy the framework provided by many-sheeted space-time [K58] leads to a general vision about the role of MEs, magnetic flux tubes and magnetic mirrors allowing to understand the fundamental recognition mechanisms of bio-molecules in terms of electromagnetic bridges defined by MEs and magnetic flux tubes. This vision allows to build a general model for paranormal phenomena and the same fundamental mechanisms seem to be behind astonishingly wide repertoire of poorly understood phenomena in the borderlines of the existing science.

An important piece in the puzzle comes from the scaling law of homeopathy [K58]. The law states that high and low frequencies accompany each other, the frequency ratio being $f_{high}/f_{low} \simeq 2 \times 10^{11}$ in the simplest situation (the ratio can actually vary). The TGD based interpretation is that ELF MEs are responsible for quantum entanglement in macroscopic, even astrophysical, length scales. Micro-wave (in particular) MEs propagating effectively as mass-less particles along ELF MEs in turn induce self-organization by serving effectively as “food” of the plasmoidic life forms at the receiving end. This mechanism would be behind both the endo- and exogenous realizations of intentions as actions, that is ordinary motor actions and phenomena like remote healing and psychokinesis.

Also sensory representations at the personal magnetic canvas and magnetosphere rely on this mechanism, and in this case life-forms are mental images getting at least partially their metabolic energy from brain. This picture which in fact emerged from a model of a rather exotic event (Fatima Marian apparition) provides a view about how low and high frequency MEs are involved with the bio-control, sensory representations, and remote mental interactions. Also a general view about UFO experiences emerges.

One can imagine several interpretation for the scaling law of homeopathy discussed in [K58]. The following interpretation is one of them.

1. The $v = L \times f_{low} = c \times (f_{ELF}/f_h)$ scaling law, which first emerged in the quantum model of EEG and later in the model of homeopathy, can be understood and generalized. What the scaling law means that system with size L and generating MEs with frequencies coming as multiples of $f_h = c/L$ is sensitive to only few low frequencies f_{low} and this is essentially due to the fact that various mechanical, chemical, or electromagnetic wave phenomena propagate only with preferred velocities v .
2. EEG waves and the wave motion associated with homeopathic effects are only special instances of the scaling law. Ca^{++} waves which proliferate living systems provide an especially important realization for the law: the velocity v varies from one nm/s to one m/s and thus spans nine orders of magnitude but varies around a given value typically only by a factor of order three.
3. Given scaling law allows a concrete interpretation in terms of mechanisms transforming low frequency MEs to high frequency MEs generating coherent photons and vice versa. This means transformation of macroscopic control commands to molecular control commands and molecular sensory data to macro-sopic sensory representations. $f_h \leftrightarrow f_{low}$ transformation is central in both the generation of the low frequency em MEs defining sensory projectors and the realization of the motor commands represented in terms of low frequency MEs transformed to high frequency MEs via $f_{low} \rightarrow f_h$ transformation.

4. A much deeper explanation for the scaling law of homeopathy is based on the quantization of Planck constant. Number theoretical arguments suggest a general formula for the allowed values of λ [K47] as $\lambda = n$ where n characterizes the quantum phase $q = \exp(i\pi/n)$ characterizing Jones inclusion [K141]. The values of n for which quantum phase is expressible in terms of squared roots are number theoretically preferred and correspond to integers n expressible as $n = 2^k \prod_n F_{s_n}$, where $F_s = 2^{2^s} + 1$ is Fermat prime and each of them can appear only once. The lowest Fermat primes are $F_0 = 3, F_1 = 5, F_2 = 17, F_3 = 257, F_4 = 2^{16} + 1$. The prediction is that also n -multiples of p -adic length scales are possible as preferred length scales.

The scaling factor 2×10^{11} corresponds with 1.5 per cent accuracy to the integer $n_F = 2^{36} \times 3 \simeq 2.03 \times 10^{11}$ defining a Fermat polygon. This suggests an interpretation in terms of a decay of dark photon with a given wave-length to a bundle of n_F ordinary photons with the same wavelength. The energy of the dark photon would be by a factor n_F higher. This process could serve as an effective tool of bio-control. Dark photon could also transform to an ordinary photon with wavelength shorter by factor $1/n_F$. Quite generally, integers n_F defining Fermat polygons are a reasonable guess for the generalization of the scaling law of homeopathy and the search for these scaling factors could provide an experimental means of identifying the values of Planck constant relevant for living matter.

The time units of everyday life could reflect the properties of the dark matter hierarchy responsible for the control of living matter, in particular those of the sub-hierarchy defined by Fermat polygons. Indeed, one year corresponds to $n_F = 4 \times 3$ months, one month to $n_F = 2 \times 3 \times 5$ days, one day to $n_F = 8 \times 3$ hours, one hour to $n_F = 60 = 4 \times 3 \times 5$ minutes, and one minute to $n_F = 60$ seconds.

TGD inspired quantum biology and number theoretical considerations suggest preferred values for $r = \hbar/\hbar_0$. p -Adic length scale hypothesis favors powers of two as values of r . Mersenne primes $M_k = 2^k - 1$, $k \in \{89, 107, 127\}$, and Gaussian Mersennes $M_{G,k} = (1 + i)k - 1$, $k \in \{113, 151, 157, 163, 167, 239, 241, \dots\}$ are expected to be physically highly interesting and up to $k = 127$ indeed correspond to elementary particles. The number theoretical miracle is that all the four scaled up electron Compton scales $L_e(k) = \sqrt{5}L(k)$ ($k \in \{151, 157, 163, 167\}$) are in the biologically highly interesting range 10 nm-2.5 μm). The question has been whether these define scaled up copies of electro-weak and QCD type physics with ordinary value of \hbar . The proposal that this is the case and that these physics are in a well-defined sense induced by the dark scaled up variants of corresponding lower level physics leads to a prediction for the preferred values of $r = 2^{k_d}$, $k_d = k_i - k_j$. This proposal will be referred to as Mersenne hypothesis.

The model of bio-photons

The model of bio-photons emerged as a natural application of these ideas. Simple mathematical facts about the decay of the delayed luminescence induced by an external perturbation like light signal, lead to a model in which pairs of positive and negative energy MEs transversal to and moving in opposite directions along DNA strand and it conjugate generate coherent bio-photons. What is important is that a rather detailed model for how MEs and supra current circuits interact results. And most importantly, it becomes clear that negative energy MEs, perhaps the most science fictive piece of the new physics predicted by TGD, are indeed there and could be identified as space-time correlates for phase conjugate photons.

Topological self-referentiality

The longstanding problem has been the lack of understanding about how MEs relate to the existing physics and chemistry. Thus there has been a chronic uncertainty about whether MEs really are there or not, to say nothing about quantitative models for the dynamics and interaction of MEs with ordinary matter. This frustrating situation changed dramatically with the discovery of the topological self-referentiality, which means that topological field quanta of the classical fields, in particular MEs and magnetic flux tubes, associated with the material system provide a topological representation for the theory about the material system. In particular, and very importantly, negative energy MEs provide representation for the binding energies.

Generation of coherent quantum states and generation of usable energy as sides of the same coin

The generation of bound states with binding energy liberated as a usable energy allows one particular realization of the quantum credit card mechanism. In this case absorption of negative energy photons (or more general bosonic quanta) would lead to a formation of the bound state. The transition between two bound bound states is a more general manner to realize the mechanism.

A more concrete model is in terms of the time mirror mechanism. Negative energy topological light rays are expected to be accompanied by negative energy negative energy photons identifiable as phase conjugate photons. They represent a negative energy signal sent into the geometric past where it is reflected back and possibly amplified. This can occur for instance when negative energy (phase conjugate) photons are absorbed by a population inverted laser so that cascade like dropping of atoms to the ground state occurs and generates much strong positive energy signal received by the sender of the negative energy signal.

In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant \hbar_{eff} so that cyclotron energy would be liberated.

Time mirror mechanism could make possible new technologies such as instantaneous remote energy utilization, instantaneous active remote sensing, and instantaneous communications over arbitrarily long distances. Time mirror mechanism is an essential element in the models of remote metabolism, long term memory, intentional generation of motor actions, sensory perception, and remote mental interactions.

The generalization of four-wave mechanism involving generalization of standing waves provides a more concrete model of time mirror mechanism and provides a mechanism of remote metabolism in which system sucks energy from environment by sending negative energy particles such as phase conjugate photons. The geometric time reversal of second law is a signature of the process and the decay of system looks like self-assembly from the point of view of observer with standard arrow of geometric time. Generalized four-wave mechanism provides also a model over unity energy production and classical communications to the geometric past. In TGD inspired theory of consciousness and bio-matter this mechanism is central and underlies the models of metabolism, intentional action, and long term memory.

This observation leads to a quantum vision about energy economy in living matter: generation of the macroscopic coherence involving also binding of mental images to larger ones and liberation of a usable energy are different sides of the same coin. Besides, or perhaps even instead, the ordinary metabolism, quantum metabolism should be key element of living matter. Indeed, also ordinary metabolism might be accompanied by the effective over-unity energy production implied by the generation of quantum bound state entanglement with accompanying emission of negative energy photons say. This should reflect experimentally as apparently miraculous ability of the organism to cope without the use of the metabolic energy (brings in mind the stories about the feats of yogies!). Anomalies of this kind have been indeed observed at the level of neuronal metabolism and nano-biology is just questioning the basic assumptions of the Newtonian biology.

Left-brain-right brain, DNA strand-conjugate strand

Second vision is that various binary structures such as DNA and lipid layers of the cell membrane apply a division of labor analogous to what happens between left and right brain hemispheres. The first member of the pair is specialized to generate bound state entanglement and is accompanied by negative energy MEs whereas second member is accompanied by positive energy MEs providing usable energy. This energy in turn makes possible processes like nerve pulse propagation and DNA transcription. The generation of ME pairs could be actually a universal mechanism of energy liberation in living matter. Even right and left brain hemisphere would apply similar division of labor: at this level bound state entanglement would be a quantum correlate for higher level notions like creativity and spirituality. This division of labor seems to continue even to the level of society.

Information molecules as quantum links in quantum web

The third vision relates to the deeper interpretation of chemical communications and biological information molecules. There are full reasons to believe that substructures of these molecules can have bound state entanglement with the surrounding world. This entanglement can be interpreted in terms of “telepathic” quantum communications. In fact, I introduced already few years ago the notion semitrance as entanglement with higher level selves but at this time I had not yet understood that quantum jump involves also state function preparation process realized as a cascade of self measurements against which only bound state entanglement is stable.

The bound state entanglement represented by the negative energy MEs is very much like a link to web in email and the transfer of the neural transmitters from the axon to the postsynaptic neuron is like an email message with a set of quantum links to the quantum web represented by the state of the neural transmitter + environment. Note that this means that information content of the message can be very high in this case, much higher than the single bit of the neural net models. Same should hold true for information molecules in general. In this chapter this vision will be touched only very briefly.

I cannot avoid the temptation to relate this new vision to the situation in what is called globalizing world. The proponents of the market economy emphasize the deterministic nature of world economy as justification for the breakdown of well-fare society relying on social justice and mutual caring. Rather, the game theoretic view about society as a collection of individuals competing furiously to steal maximum amount of money is the key piece of this philosophy. Commitment is a word often used by our leaders: this commitment is not however stable and continues only as long as the committing person has not found an organization guaranteeing even more astrophysical salary. The foregoing considerations suggests a different view about society. Suppose that the generation of bound states at the level of society is a physical correlate for commitment. If so, commitment would mean the ability to generate usable energy from “nothing”. This view would provide more than a metaphorical justification for the belief that the society based on trust and real commitment is able to solve problems which seem completely insurmountable when seen from the desperately narrow social-Darwinistic game-theoretic perspective of the modern market economy.

In this form the idea remains still at the level of philosophy. The model for DNA as topological quantum computer [K3], which in turn inspired a model for protein folding [K7], leads to a detailed realization of this idea.

1. The magnetic flux tubes connecting various biomolecules and act as braid strands carrying four different colors corresponding to nucleotides A, T, G, C and represented as quarks u, d and their antiquarks u_c, d_c . The flux tubes can end to donors of hydrogen bonds and in this case the flux tube corresponds to hydrogen bond.
2. Acceptors of hydrogen bonds (aromatic rings, $O =$ atoms) act as plugs in the network in the sense that there is incoming flux tube and outgoing flux tube with the same color. The molecules XMP , $X = A, T, G, C$ and also their XD and XT variants could act as standardized plugs. A weaker hypothesis is that phosphates take this role. In this framework the ATP molecule moving to F_1 catalyst (molecular machine) would be a plug in the flux tube and $ATP \rightarrow ADP + P_i$ process would cut this flux tube and form a connection to the location of F_1 . This process would be the basic process modifying the network defined by colored flux tubes and would typically initiate topological quantum computation. The process would also mean the formation of a link in the web defined by the flux tubes and the basic job of ATP molecules would be to carry these plugs to various places to form new connections. Reconnection mechanism for the flux tubes would be the mechanism allowing the modification of this web.

Earlier ideas about how motor control is realized

The basic ideas behind TGD based view of motor control developed before the discovery of dark matter hierarchy are following.

1. Computer sitting at its own terminal metaphor with astrocytes taking the role of keyboard.

2. Gardener metaphor: control means essentially a selection of patterns from primordial chaos constrained only by sensory input by amplifying these patterns by providing the needed energy. Since astrocytes are metabolic sources of brain, they are good candidates for controllers. Also the need to cleanly separate motor control signals from sensory signals supports this view.
3. Quantum metabolism: quantum control involves also signals propagating to the geometric past having identification as phase conjugate photons and inducing transitions of subsystems of brain and body to lower energy levels. As a special case quantum bound states are formed and binding energy is liberated as a metabolic energy. This requires what might be called over-unity energy production. The anomalously low oxidative metabolism at neuronal level could be a signature of this mechanism.
4. Puppets in string mechanism: strings start already from the magnetic body. Indeed, to gain precise control it is necessary to locate the end of the ME precisely on the desired point in brain. This might be too strong a requirement: it could be that all parts of the brain receive the same control signal and interpret it in their own manner. Resonance is an essential element of the interpretation mechanism: various structures pick up only certain frequencies from the control command and amplify and transform the signal at these frequencies to various kinds of chemical, mechanical and electrical signals. Even in this case it seems that pre-existing p-adic or real MEs is the only reasonable option. p-Adic MEs would have interpretation as geometric correlates of intentions. Corresponding magnetic flux tube structures are pre-existing and real.
5. Motor control and sensory input must separate from each as completely as possible. If motor control relies on negative energy MEs and sensory representations on positive energy MEs, this is achieved. This would mean that magnetic bodies suck the metabolic energy needed to build photons associated with scaled up variants of EEG from brain and body. This energy is an important factor in metabolism since the energies of photons involved must be above the thermal threshold at room temperature.
6. The communication of the control signals must be based on a highly symbolic representation. The prototype realization for this is monochromatic reference wave generating a complex hologram. For obvious reasons this is not a safe option: some kind of linguistic structure allowing to eliminate the possibility that undesired signals are interpreted as control signals must be present. Natural language is the highest level language that we know. This suggests that the signals represented by negative energy MEs are transformed to Ca^{++} waves and the frequency for their generation correlates with the level of dark matter hierarchy involved. Ca^{++} waves indeed appear in wide frequency scale.

Internal speech would very naturally represent this communication from the sensory canvas. Internal speech involves only single voice at time and this suggests that only one command is given at one time and all astrocyte synticia of the cortex receive it and interpret it in their own manner. There could be an entire hierarchy of internal speeches corresponding to various frequency and length scales and levels of dark matter hierarchy and also other wave forms than sound could define internal speeches.

9.6.2 Generalized-Four Wave Mechanism As A Basic Mechanism Of Remote Metabolism

Generalized four-wave mechanism provides a concrete realization for the more general time mirror mechanism underlying remote metabolism and many other mechanism important for the functioning of the living matter in TGD Universe. Generalized four-wave mechanism also provides a connection with the existing physics of phase conjugate waves.

Time mirror mechanism

Time mirror mechanism (see **Fig.** <http://tgdtheory.fi/appfigures/timemirror.jpg> or **Fig.** ?? in the appendix of this book) could make possible new technologies such as instantaneous remote

energy utilization, instantaneous active remote sensing, and instantaneous communications over arbitrarily long distances. Time mirror mechanism is an essential element in the models of remote metabolism, long term memory, intentional generation of motor actions, sensory perception, and remote mental interactions. What happens that negative energy topological light rays propagating to the direction of the geometric past are reflected back in time direction and return as positive energy topological light rays (photons could accompany the rays).

This apparently paradoxical sounding language makes sense since the experienced time corresponds to a sequence of quantum jumps recreating space-time surface again and again and the correspondence between these times follows from quantum-classical correspondence: the contents of conscious experience in the essentially four-dimensional classical universe are dominated by contributions, which are sharply localized with respect to the geometric time. This creates the illusion that the classical universe is 3-dimensional. It is essential that the field equations determining the space-time surfaces as field analogs of Bohr orbits are not fully deterministic. Only this makes it possible for the classical dynamics to mimic the non-deterministic quantum dynamics.

Negative energy topological light rays can induce the dropping of ions from atomic to larger space-time sheets. The liberated zero point kinetic energy means that the system can act as an over-unity energy source. Negative energy topological light rays, presumably having phase conjugate laser waves as standard physics counterparts, would be accompanied by negative energy photons and these would induce the dropping of charged particles to larger space-time sheets without emission of photons. The experiments of Feinberg, in particular the experiment in which a chicken was irradiated by phase conjugate laser waves, demonstrate that the system was transparent to phase conjugate laser waves at visible lengths. Indeed, if the phase conjugate photons have negative energies above the thermal energy, say at energies corresponding to visible wave lengths, there is no excited atomic system able to absorb negative energy photons inducing the return to the ground state.

In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant \hbar_{eff} so that cyclotron energy would be liberated. In the following only the “dropping” option is discussed.

The pairs of atomic and larger space-time sheets can act as many-sheeted population inverted lasers with frequencies which are universal constants of nature, and defined as differences of zero point energies whose values are predicted by the p-adic length scale hypothesis. If the intensity of the negative energy photons is above some critical value, the particles in the excited state of the many-sheeted population inverted laser drop to the ground state in a cascade like manner (the probability of dropping of charged particle is proportional to the number of charged particles already present at larger space-time sheet and thus to the intensity and duration of negative energy topological light ray irradiation). The time reflection thus involves an amplification and negative energy photons serve only the role of controller. The system becomes over-unity energy source making possible remote energy utilization.

Four-wave interaction and time mirror mechanism

Four-wave interaction is the basic mechanism producing phase conjugate laser waves, and TGD approach leads to a generalization of this [I72] [K21]. Four-wave interaction becomes the basic mechanism of intentional action and is behind the basic biological and brain functions like (actually remote) metabolism and long term memory. The findings of Tiller [J123] about physical correlates of intentional action find a nice explanation in this framework.

There are several open questions about four-wave interaction. Could four-wave interaction or its generalization provide a deeper understanding of the scaling law of homeopathy stating that low and high frequencies appear in pairs [K58] ? Could the basic function of probe and conjugate beams be the amplification of the standing wave interference pattern by remote metabolism? Does the standing wave formed by the reference beams serve as a kind of standardized hologram? Is it possible to generalize the notion of hologram in order to get rid of the reference beams?

The standing wave interference pattern represents a synchronous oscillation of the entire

system and would be an excellent physical correlate for the ability of living organisms to act as coherent wholes. The standing wave resulting as the interference pattern of waves propagating in opposite directions would serve kind of a standardized hologram parameterized by the wavelength λ_h . The interference pattern can be also kicked into a motion by Lorentz boost, and the propagation velocity of the interference pattern is an additional characteristic of the pattern.

Probe and phase conjugate beams in four-wave interaction could in turn be interpreted in terms of remote metabolism. System sends negative energy topological light rays (or massless extremals, MEs) to the geometric past and receives as a response positive energy MEs, and amplification can occur in this process so that negative energy signal serves only a role of control signal. Its generation would utilize the energy provided by the remote metabolism. The emission of negative energy ME would switch on the positive energy laser of the geometric past generating probe beam. The energy source could be system in its geometric past or some system in the environment.

Standing wave is basic element of the mechanism and its generation would require energy obtained by emitting phase conjugate photons. Standing wave need not result only as an interference of classical em wave propagating in opposite directions, but could correspond to any standing wave. Plasma resonances are an especially interesting candidate for a standing wave since plasma frequency does not depend on wave vector at all in lowest approximation. This means that there is no dispersion and the pattern formed by plasma waves is oscillatory. I have indeed proposed that this kind of plasma wave patterns are in key role in living matter. The plasma wave pattern would get the energy of its self-organization by sending (say) negative energy photons.

One can imagine a metabolic hierarchy which is obtained by a time reversal from the dissipation hierarchy for which energy from long length scales gradually dissipates to short length scales. The dissipation of the energy of a hydrodynamic vortex by the gradual decay to smaller vortices is a basic example of this process. Now this kind of process would be replaced by a self-assembly starting from the most energetic level and involve radiation of phase conjugate waves with decreasing frequency scales. The lowest level would correspond to ordinary metabolic mechanism, magneto-static waves could be at the next level and the counterparts of magneto-static waves for Cooper pairs at magnetic flux tubes could be also present and correspond to very low frequencies.

In living matter metabolic energy feed corresponds to the “pumping” and drives protons back to the atomic space-time sheets, and the same would be true now. This hints to a somewhat pessimistic conclusion from the point of view of over unity enthusiast: if the system gains its energy by dropping its own protons to larger space-time sheets, it cannot work for too long. This might relate to the continually occurring optimistic reports about free energy production followed by silence. The point of over unit technology would not be however tapping endlessly energy about vacuum but the possibility of remote metabolism which could make unnecessary for system to carry energy storages with itself and allow extreme flexibility and instantaneous generation of energy when needed.

TGD view about four-wave mechanism

It is not obvious what the description of four-wave mechanism is at the basic level in TGD framework. In Maxwellian approach one introduces non-linear F^4 term in the Lagrangian, where F is field strength. This approach must be replaced by something else in TGD level if one wants a microscopic description.

To end up with this description by making first the question how to understand amplitude modulation. Even this is not enough. One must ask what is the first principle description for the linear superposition of fields in TGD framework.

1. Superposition of fields in terms of flux quanta

In TGD Universe gauge fields are replaced with topological field quanta. Examples are topological light rays, magnetic flux tubes and sheets, and electric flux quanta carrying both magnetic and electric fields. Flux quanta form a fractal hierarchy in the sense that there are flux quanta inside flux quanta. It is natural to assume quantization of Kähler magnetic flux. Braiding and reconnection are basic topological operations for flux quanta.

One important example is the description of non-perturbative aspects of strong interactions in terms of reconnection of color magnetic flux quanta carrying magnetic monopole fluxes [K53,

K74]. These objects are string like structures and one can indeed assign to them string world sheets. The transitions in which the thickness of flux tube increases so that flux conservation implies that part of magnetic energy is liberated unless the length of the flux quantum increases, are central in TGD inspired cosmology and astrophysics. The magnetic energy of flux quantum is interpreted as dark energy and magnetic tension as negative “pressure” causing accelerated expansion.

This picture is beautiful and extremely general but raises challenges. How to describe interference and linear superposition for classical gauge fields in terms of topologically quantized classical fields? How the interference and superposition of Maxwellian magnetic fields is realized in the situation when magnetic fields decompose to flux quanta? How to describe simple systems such as solenoidal current generating constant magnetic field using the language of flux quanta?

The basic question concerns the elegant description of superposition of classical fields in terms of topological field quanta. What it means that electromagnetic fields - say magnetic - fields superpose.

1. In Maxwell’s linear theory the answer would be trivial but not now. Linear superposition holds true only inside topological light rays for signals propagating in fixed direction with light velocity and with same local polarization. The easy solution would be to say that one considers small perturbations of background space-time sheet and linearizes the theory. Linearization would apply also to induced gauge fields and metric and one would obtain linear superposition approximately. This does not look elegant. Rather, quantum classical correspondence requires the space-time counterpart for the expansion of quantum fields as sum of modes in terms of topological field quanta. Topological field quanta should not lose their identity in the superposition.
2. In the spirit of topological field quantization it would be nice to have topological representation for the superposition and interference without any linearization. To make progress one must return to the roots and ask how the fields are operationally defined. One has test particle and it experiences a gauge force in the field. From the acceleration of the test particle the value of field is deduced. What one observes is the superposition of gauge forces, not of gauge fields.
 - (a) Let us just assume that we have two space-time sheets representing field configurations to be effectively superposed. Suppose that they are “on top” of each other with respect to CP_2 degrees of freedom so that their M^4 volumes overlap. The points of the sheets representing the field values that would sum in Maxwell’s theory are typically at distance of CP_2 radius of about 10^4 Planck lengths. Wormhole contacts representing the interaction between the field configurations are formed. Hence the analog of linear superposition does not hold true exactly. For instance, amplitude modulation becomes possible. This is however not essential for the argument.
 - (b) Test particle could be taken to be fermion which is simultaneously topologically condensed to both sheets. In other words, fermionic CP_2 type almost vacuum extremal touches both sheets and wormhole throats at which the signature of the induced metric changes is formed. Fermion experiences the sum of gauge forces from the two space-time sheets through its wormhole throats. From this one usually concludes that superposition holds true for the induced gauge fields. This assumption is however not true and is also un-necessary in the recent case. In case of topological light rays the representation of modes in given direction in terms of massless extremals makes possible to realize the analogy for the representation of quantum field as sum of modes. The representation does not depend on approximate linearity as in the case of quantum field theories and therefore removes a lot of fuzziness related to the quantum theory. In TGD framework the bosonic action is indeed extremely non-linear.
3. This view about linear superposition has interesting implications. In effective superposition the superposed field patterns do not lose their identity which means that the information about the sources is not lost - this is true at least mathematically. This is nothing but quantum classical correspondence: it is the decomposition of radiation into quanta which allows to conclude that the radiation arrives from a particular astrophysical object. It is

also possible to have superposition of fields to zero field in Maxwellian sense but in the sense of TGD both fields patterns still exist. Linear superposition in TGD sense might allow testing using time dependent magnetic fields. In the critical situation in which the magnetic field created by AC current passes through zero, flux quanta have macroscopic size and the direction of the flux quantum changes to opposite.

2. The description of amplitude modulation and four wave action in TGD Universe

Also the phenomena of amplitude modulation and four-wave interaction would be effects appearing as quantal reactions of charged particles to the presence of space-time sheets carrying fields. They need not be present for induced gauge fields. One might perhaps even say that these effects appear only at the level of conscious perception involving quantum jumps but not at the level of classical fields.

The summation of effects of em fields can induce amplitude modulation. If charged particles have topological sum contacts to the two space-time sheets carrying classical fields with different frequencies, the rate for quantum jumps is proportional to the modulus squared for the sum of the forces caused by these fields, and one obtains amplitude modulation visible as different and sum of the frequencies involved. In the case of massless extremals the sum and difference of frequencies appear only if MEs corresponding to opposite directions of 3-momentum are present. This leads to an effect that would be regarded as being caused by a standing electromagnetic wave. MEs correspond to waves propagating in single direction for a given sign of frequency, and in TGD framework it is highly implausible that standing waves could be realized as classical gauge fields.

Similar description applies to four-wave mechanism. Four space-time sheets can give rise to the sums of four frequencies appearing with both signs in the sum and the temporally constant effect is obtained when the sum of the frequencies vanishes.

Fröhlich's coherent dipole oscillations and generalized four-wave mechanism

Any oscillation for which frequency is independent of the wave vector defines an ideal generalized standing wave able to suck energy from the environment by sending phase conjugate photons at the frequency of the wave. Plasma oscillations are basic example of this kind of waves. Magnetostatic waves, which might be relevant for the strange behavior of rotating magnetic systems and bifilar coils [K131], represent a second example. Now however the frequency depends on the angle θ between the wave vector and magnetic field. One can wonder whether magnetostatic waves could be replaced by their electret versions for which the permanent electric dipoles possessing spin oscillate around the equilibrium positions in self-generated electric field and experience the torque $p \times E$.

1. Dispersion relation for the magnetostatic waves of magneto-electret

The equations for magnetostatic waves [D9] can be generalized in a straightforward manner. The units in the sequel is chosen such that one has $\epsilon_0 = \mu_0 = c = \hbar = 1$.

1. The equation relating angular momentum J to magnetic momentum μ : $J = \gamma\mu$ and the expression for the magnetic torque $\tau_m = \mu \times B$ are central. Now also the electric torque $\tau_e = p \times E$ is present.
2. Assume that the dispersive medium is magnetically linear but as an electric has electric and polarization fields E_0 and P_0 satisfying $E_0 = -P_0$ even in the absence of external field D :

$$\begin{aligned} B &= H + M \quad , \quad D = E + P \quad , \\ H &= \mu B \quad , \quad D = \epsilon(E + P_0) \quad , \quad P = (\epsilon - 1)E + \epsilon P_0 \quad . \end{aligned} \tag{9.6.1}$$

D clearly vanishes for the ground state.

3. Assume that ground state fields have constant values so that one has

$$\begin{aligned} M &= M_0 + m(t) , & H &= H_0 + h(t) , \\ E &= P_0 + e(t) , & D &= \epsilon e(t) , & P &= P_0 + p(t) = \epsilon P_0 + (\epsilon - 1)e(t) . \end{aligned}$$

The further assumption is that M_0, B_0 and P_0 are in the same direction, say z-direction, and that m, b, p, e are orthogonal to z-direction.

4. The equations of motion for the magnetization follow from those for single magnetic moment

$$\begin{aligned} \frac{dm}{dt} &= \gamma(M \times H + P \times E) = \frac{\gamma e}{M}(M_0 \times h - H_0 \times m - \epsilon e \times P_0) , \\ \gamma &= \frac{ge}{2M} \end{aligned} \quad (9.6.2)$$

M can be taken as a mass scale characterizing the electric dipole as a quantum system as a magnetic system. The first naïve guess would be that M is identifiable as the mass of the dipole and g denotes the Lande factor appearing in the expression of the magnetic moment in terms of spin $\mu = geS/2M$, e denotes elementary charge. Note that the electric dipole need not possess a net charge and therefore the net charge q appearing in the formula in the case of elementary particle is replaced by $q = e$ and the generalized Lande factor g characterizes the spin of the atom or a molecule. In the case of quantum coherence in spin degrees of freedom, the magnetic moment of the molecule would in a reasonable approximation result by the summation of angular momenta of composite atoms determining also the net magnetic moment. Hence the mass scale could be actually given by the mass of nucleon or even electron whose contribution dominates over nuclear contribution by a factor of about $m_p/m_e \simeq 2 \times 10^3$. In this case the mass scale M would correspond naturally to electron mass.

5. Maxwell's equation $\nabla \times E = -\partial_t B$ for plane waves gives

$$e = -\frac{k}{\omega} \times b , \quad (9.6.3)$$

and one can write $e \times P_0 = P_0 \cos(\theta) b$ so that the equation of motion for the magnetization reads as

$$\begin{aligned} i\omega m &= \gamma [M_0 \times h - H_0 \times m - \epsilon P_0 \cos(\theta) b] \\ &= \frac{\gamma e}{M} [(M_0 - \epsilon P_0 \cos(\theta)) h - (H_0 + \epsilon P_0 \cos(\theta)) m] . \end{aligned} \quad (9.6.4)$$

This equation differs from the equation in a purely magnetostatic case only in that one must replace the parameters H_0 and M_0 with modified parameters:

$$\begin{aligned} M_0 &\rightarrow M_0 - \epsilon P_0 \cos(\theta) , \\ H_0 &\rightarrow H_0 + \epsilon P_0 \cos(\theta) . \end{aligned} \quad (9.6.5)$$

6. From the equation above one can express m in terms of h using the so called Polder's susceptibility tensor

$$\begin{pmatrix} m^x \\ m^y \end{pmatrix} = \begin{pmatrix} \chi & -i\kappa \\ i\kappa & \chi \end{pmatrix} ,$$

$$\chi = \frac{\omega_0\omega_1}{\omega_0^2 - \omega^2} , \quad \kappa = \frac{\omega\omega_1}{\omega_0^2 - \omega^2} . \quad (9.6.6)$$

In a purely magnetostatic case the parameters are counter parts of Larmor frequencies in fields H and M and satisfy $\omega_0 = \omega_H = e\gamma H_0/M$ and $\omega_1 = \omega_M = e\gamma M_0/M$, where M denotes the mass of the magnetic dipole. In the more general case one has

$$\begin{aligned} \omega_0 &\rightarrow \gamma(H_0 + \epsilon P_0 \cos(\theta)) , \\ \omega_1 &\rightarrow \gamma(M_0 - \epsilon P_0 \cos(\theta)) . \end{aligned} \quad (9.6.7)$$

7. Maxwell's equation $\nabla \cdot B = 0$ and the assumption $\nabla \times H = 0$ implying $H = -\nabla\Psi$ combined with $B = \mu \cdot H$, with dynamical permittivity tensor

$$\mu = \begin{pmatrix} 1 + \chi & -i\kappa & 0 \\ i\kappa & 1 + \chi & 0 \\ 0 & 0 & 1 \end{pmatrix} , \quad (9.6.8)$$

gives

$$(1 + \chi)(\partial_x^2 + \partial_y^2)\Psi + \partial_z^2\Psi = 0 . \quad (9.6.9)$$

For plane waves one obtains the dispersion relation

$$\chi \sin^2(\theta) = -1 . \quad (9.6.10)$$

Substituting this to the expression of ξ one obtains the dispersion relation

$$\omega^2 = \omega_0(\omega_0 + \omega_1 \sin^2(\theta)) . \quad (9.6.11)$$

2. Dispersion relation for a pure electret

Consider now the special case $H_0 = M_0 = 0$. The dispersion relation gives now

$$\omega = \frac{eg}{2M} P_0 \cos^2(\theta) = \omega_L \frac{\epsilon P_0}{B} \cos^2(\theta) . \quad (9.6.12)$$

The frequency depends only on the direction of propagation and for the wave vectors in the cone $\theta = \text{constant}$ frequency is same for all Fourier components so that the situation is almost ideal since the formation of 2-dimensional periodically recurring self-organization patterns is possible. Note that the allowed wave vectors form a double cone. The frequency coding of the angle θ occurs.

The external magnetic field is replaced by the polarization field in the formula for the Larmor frequency. In the expression for the magnetic moment in terms of spin ($\mu = gqS/2M$) the mass of the elementary particle is replaced by the mass M of the dipolar molecule. Recall however that in case of quantum coherence even electron mass would be more appropriate mass scale. For instance, if macroscopic quantum phase consisting of electron Cooper pairs is in question the mass scale would be $2m_e$ and spin could be rather large.

p-Adic fractality leads to an estimate for the maximal frequency of the waves as a function of the size of the electret molecule.

1. The idea that the non-quantum coherent physics of a many-particle system formed by smaller space-time sheets topologically condensed at a given space-time sheet is simulated in terms of quantum coherent physics of a space-time sheet containing them, encourages to consider the possibility that the space-time sheets of tubulin molecules possess a magnetic moment, which has an order of magnitude equal to a thermal expectation value of the magnetic moment in the shorter length scales. There would be of course hierarchy of temperatures involved. The magnetic moment could be due to a condensate of Cooper pairs of electrons at a magnetic flux tube structure accompanying the tubulin molecule.
2. p-Adic fractality encourages to think that the net electronic spin and thus magnetic moment is same in each p-adic length scale and thus of order of electronic magnetic moment. If similar scaling holds true for the electric dipole moment assumed to be $p = na$, $a = L(137)$ in atomic length scale, then the polarization in the p-adic length scale $L(k)$ would satisfy

$$P_0(L(k)) = \frac{n}{a^2} \times \left[\frac{L(137)}{L(k)} \right]^3 = \frac{n}{a^2} \times 2^{3(137-k)/2} .$$

Taking the Larmor frequency $f_0 = 12$ GHz of electron ($m_e = 10^{-3}m_p/2$) in the magnetic field of one Tesla ($Tesla \simeq 10^{-4}/a^2$, $a = .1$ nm for $\hbar = c = 1$) as as reference, one can write the estimate for the maximal frequency f_m as

$$f_m(k) = \epsilon n g \times 10^4 \times 2^{3(137-k)/2} \times f_0 .$$

For instance, for $k = 151$ corresponding to the length scale of 10 nm giving a good estimate for the size of a tubulin molecule, the estimate for the frequency would be $f \sim \epsilon n g \times .05$ GHz.

3. A possible connection with Fröhlich's hypothesis

If the mass scale M corresponds to the mass of the molecule, the result conforms with the hypothesis of Fröhlich [J76] that coherent electric dipole oscillations in the nanosecond scale are crucial for the functioning of the living matter. This hypothesis is a crucial piece of many quantum theories of consciousness. In TGD framework the interpretation would be different: coherent dipole oscillations would be responsible for the generation of periodically recurring (two-dimensional) mental images able to suck their energy from their environment by sending phase conjugate photons. The usual view that the energy is pumped to system by an external agent is in conflict with the goal of explaining consciousness from the first principles.

Living matter is populated by electrets but micro-tubules are perhaps the most prominent electrets from the point of view of quantum theories of consciousness. In this case the situation would be 2-dimensional from the beginning. As already found, the estimate based on the notion of many-sheeted space-time and p-adic fractality gives $f_m \sim \epsilon n g \times .05$ GHz, which is in GHz scale for $\epsilon n g \sim 20$. The dielectric constant of water is $\epsilon = 79$ for a pressure of 1 atm and temperature of 20 C so that there are good hopes that f_m corresponds to GHz scale. Of course, there is a fractal hierarchy of frequencies f_m scaling as $f_m \propto 2^{3(137-k)/2}$ ranging to the visible frequencies.

9.6.3 Explanation Of Super-Luminal Velocities In Terms Of Remote Metabolism

After the pioneering experiments of Nimtz and his collaborators 1992 [D11] a lot of evidence for effective super-luminal signal velocities has been accumulating [D27, D28]. These findings provide not only a challenge for TGD but also a means of developing the new views about time and energy to a more quantitative level. The simplest model for the super-luminality and related effects is in terms of remote metabolism associated with detectors and other instruments. Thus these experiments would give a firm grasp on phenomena at the border of dead and living matter.

General explanations for effective super-luminal velocities

Several explanations for the effective super-luminal velocities have been proposed. Quite generally, the explanations are marginally consistent with Maxwell's equations.

1. The explanation of super-luminality in terms of photon tunnelling

The explanation of Nimtz [D27, D28] for effective super-luminal velocities involves the notion of evanescent wave for which the component of the wave vector in the direction of propagation is by definition imaginary: $k = i\kappa$ so that the wave is exponentially attenuated. For one-dimensional evanescent em waves dielectric constant ϵ as a function of frequency must be negative so that also the energy density becomes negative and Nimtz suggests that this holds true generally. For 3-dimensional waves in waveguide, which are not constant in the transversal degrees of freedom, evanescent waves in vacuum are possible below cutoff frequency ω_c and are generated in a wave guide containing a narrowed portion in the original experiments of Nimtz.

The analogy with the Schrödinger equation allows the interpretation of evanescent waves in terms of photon tunnelling. The semiclassical model relies on the wave equation for non-allowed frequencies not propagating in the waveguide. The model predicts that asymptotically the time τ taken by the evanescent wave of mean frequency f to propagate through a narrowed section of length L of a waveguide does not depend on L and is $\tau \simeq 1/f$ so that arbitrary high effective signal velocities become possible in principle: note however that the exponential attenuation poses strong limitations. This effect is known as Hartman's effect, and generalizes to other geometries and also to electron tunnelling. The prediction is consistent with experiments [D11, D27, D28] so that the model provides a reasonable looking phenomenological approach to the situation. The objection is that the solutions describe stationary photon states rather than the process creating them so that the proposed interpretation of evanescent wave is correct only if the stationary solution codes in itself the process leading to it.

It has been proposed that the effective super-luminal velocities could relate to the breaking of local Lorentz invariance (LLI) [D27, D13] involving also quantum non-locality. The breaking of LLI at space-time level is possible in TGD since Poincare invariance is a symmetry of the 8-dimensional embedding space. The induced metric of space-time surface can have even Euclidian signature, which might serve as the space-time correlate for the negative value of the dielectric constant.

Also the notion of anomalous interference and the notion of hollow wave analogous to the pilot wave of Bohm have been introduced by Cardone and collaborators [D13]. The phenomenological notion of hollow wave might allow precise formulation using the notion of many-sheeted space-time.

2. The explanation of effective super-luminality in terms of remote metabolism

TGD suggests a microscopic description in terms of many-sheeted space-time by utilizing the new energy concept allowing negative inertial energies. The explanation relies on time mirror mechanism (see **Fig.** <http://tgdtheory.fi/appfigures/timemirror.jpg> or **Fig. ??** in the appendix of this book) realized in terms of the generalized four-wave mechanism and making possible remote metabolism by sending negative energy phase conjugate photons to the geometric past.

Remote metabolism can explain not only the effective super-luminality but also the effects interpreted in terms of anomalous interference effects [D13]. Detector could be seen as a self-organizing system able to suck energy by radiating phase conjugate negative energy photons to some other part of system absorbing them. This is also TGD proposal for the fundamental mechanism behind the ordinary metabolism in living systems and the model predicts that the detectors in the experiments considered behave to some extent like living systems. One can even imagine that a competition for resources occurs and that two systems do their best to suck energy from each other. The general catastrophe theoretic model of remote metabolism developed to explain the behavior of Searl device [K131] provides a starting point for the attempts to model the situation quantitatively.

In the case of the pioneering experiments of Nimtz involving a narrowed portion of wave guide the model would look as follows. When the photons in the wave cavity encounter the narrowed portion they are partially absorbed and excite higher energy states of the atoms and

electrons at the walls of the cavity. As the detector has received sufficiently many photons, which have travelled through the narrowed portion of the cavity with light velocity, the detector starts to emit negative energy photons absorbed by the excited atoms which thus return to ground states. The shape of the signal received by detector is changed and the signal peak is shifted to earlier time and this gives rise to effective super-luminal light velocity. According to the figure 4 of [D27] the tunneled signal is not obtained as a time shift of ordinary reference signal but has slightly different shape. In accordance with observations the energy received by the detector is predicted to be larger than expected.

Experiments involving super-luminal velocities

The pioneering experiments on super-luminal velocities were done by Nimtz and collaborators in Cologne 1992 [D11] using microwaves. The configuration used was a wave guide containing a narrowed portion with cross section less than one half of wavelength in both transversal directions. The finding was that the tunnelling time is asymptotically equal to $\tau \simeq 1/f$, where f is the frequency of the microwave. More generally, photon tunnelling can be realized in wave guides containing a narrowed portion, in the forbidden frequency bands of dielectric hetero-structures analogous to one-dimensional lattices, and also as the frustrated total internal reflection of a double prism, where the total reflection takes place at the boundary from a denser to a rarer dielectric medium [D28].

3. Standard theoretical description of the findings

The interpretation proposed by Nimtz for super-luminal propagation is in terms evanescent waves representing semiclassically photon tunnelling. The quantum tunnelling of photons was first discussed by Wigner and later by Hartman who deduced the independence of the tunnelling time on barrier thickness [D49]. The article of [D8] [D8] summarizes the model.

Evanescent modes correspond to waves with imaginary wave number not satisfying the dispersion relation of free massless photon. The dispersion relation $\omega^2 - k^2 - \omega_c^2 = 0$ satisfied for free propagation in the waveguide is replaced by $\omega^2 + \kappa^2 - \omega_{c,1}^2 = 0$ in the narrowed portion of the waveguide. The photons satisfying $\omega_c < \omega < \omega_{c,1}$ can propagate in the narrowed portion but are attenuated exponentially. The narrowing of the waveguide by a factor x means $\omega_c \rightarrow \omega_c/x$ so that evanescent modes appear, when x satisfies the constraint $x < \omega_c/\omega$.

In Maxwell's theory a system allowing *one-dimensional* evanescent waves must have negative dielectric constant ϵ ($c^2 = \epsilon_0\mu_0 \rightarrow \epsilon\mu < 0$) for the frequencies involved so that d'Alembert type wave equation changes to Laplacian and tunnelling cannot be regarded as a genuine propagation. A possible interpretation is in terms of breaking of Lorentz invariance. According to Nimtz, the evanescent modes seem to represent non-local fields. For one-dimensional propagation the energy density $\varepsilon = \epsilon E^2/2$ by $\epsilon < 0$ would be indeed negative. On the other hand, for 3-dimensional waveguide $\varepsilon < 0$ need not hold true. Evanescent have not been measured directly and they might represent fictitious quantities.

The so called phase time approach identifies the tunnelling time as $\tau = d\phi/d\omega$, where ϕ is the phase change over the barrier. In the examples listed above phase change is vanishing since the wave number is imaginary implying $\phi = 0$. Experimentally it has been found $\tau \simeq 1/f$ and this is believed to be due to what happens at the barrier front boundary. A quantum mechanical model for photon tunnelling originally developed by Wigner and by Hartman predicts phase-time correctly. A semiclassical description is in question since electromagnetic field does not allow interpretation as a probability amplitude.

The tunnelling occurs only below certain length scale L . An interpretation as the size of the region inside which the breaking of Lorentz invariance at space-time level takes place, has been suggested. In the experiments of Nimtz and collaborators L corresponds to the 8.8 – 9.30 cm variation range for the penetration length of evanescent wave [D11]. Second scale corresponds to an energy threshold of $E_{0,e.m.} = 4.5 \mu V$ representing the difference of voltages induced in photodiodes in two experiments in which tunnelling occurs/does not occur. In [D13] the threshold is interpreted as an energy threshold for the breaking of local Lorentz invariance.

4. TGD based explanation of effective super-luminality in terms of remote metabolism

The general TGD based description of the effective super-luminal propagation is based on

time mirror mechanism realized in terms of a generalization of the four-wave interaction involving standing wave composed of two waves propagating in opposite directions and waves representing incoming wave and phase conjugate wave. Phase conjugate negative energy photons would propagate inside negative energy massless extremals (MEs, topological light rays). Time mirror mechanism makes possible remote metabolism, and it is assumed that detector is able to remotely metabolize by sending negative energy photons to the walls of the wave guide whose atoms have been excited by the photons which have been excited.

In the following the consideration is restricted to the experiment [D11] of Nimtz in which waveguide contains a narrowed portion.

1. When the photons with frequencies below the cutoff frequency of the narrowed portion of the waveguide encounter the narrowed portion they are partially absorbed and excite higher energy states of the atoms and electrons at the walls of the cavity. When the detector has received sufficiently many photons, which have travelled through the narrowed portion of the cavity with the normal light velocity, the detector starts to emit negative energy photons absorbed by the excited atoms which thus return to ground state. The shape of the detector signal changes and the peak of the signal received by the detector is shifted to an earlier time. According to the figure 4 of [D27] the shape of the signal indeed changes. The outcome is an effective super-luminality.

If the change of the shape is such that it corresponds in the frequency domain to the phase shift induced by the translation $t \rightarrow t - \Delta\tau$ in the argument of the Fourier component $\exp(i\omega t)$, with $\Delta\tau$ given as the difference

$$\Delta\tau(\omega) = \tau_R - \tau = \frac{L}{c} - \frac{2\pi}{\omega} \quad (9.6.13)$$

of the real time τ_R taken to propagate through the barrier and of the semiclassical tunnelling time $\tau(\omega)$, the theory makes same predictions as the semiclassical approach.

2. The prediction is that the detected signal is somewhat stronger than predicted by the standard theory. This has indeed been observed and is formulated in [D13] in terms of the effective energy threshold, which corresponds to the voltage difference $E_{0,e.m} = E_B - E_A \simeq 4.5 \mu\text{V}$, where A (B) corresponds to the situation in super-luminal propagation occurs (does not occur). Why this should be the case, is not obvious in the semiclassical model.

5. Could strong breaking of local Lorentz invariance occur at the space-time level?

The quantum-classical correspondence states that many-sheeted space-time realizes also the phenomenological smoothed out descriptions of the physical system using a hierarchy of larger space-time sheets: many-sheeted physics performs self-mimicry. This philosophy might apply also to the description of photon tunnelling.

In TGD Poincare invariance corresponds to the symmetries of the embedding space and TGD predicts the possibility of space-time sheets with Euclidian signature of metric and thus a dramatic breaking of local Lorentz invariance at space-time level. The physical interpretation of these space-time sheets has remained open. In spirit of quantum classical correspondence one can wonder whether the induced metric could have Euclidian signature for the standing microwave space-time sheet so that the negative value of dielectric constant $\epsilon(\omega)$ necessary for one-dimensional evanescent waves would have a direct space-time correlate in TGD framework. Even the effectively one-dimensional approximate description of the situation with length scale resolution larger than the transversal size of the narrowed portion of the waveguide could have this kind of space-time correlate.

If the standing microwave space-time sheets with Euclidian signature of the induced metric are vacuum extremals, the resulting flexibility gives good hopes about the correspondence with the tunnelling interpretation of the evanescent waves. Of course, TGD description remains a bundle of ideas and precise quantitative model is not yet possible.

6. Alternative explanation in terms of drift of negative energy MEs does not work

A second explanation imaginable in TGD framework would rely on the drift of the negative energy MEs generated at the end B of narrowed portion and send to the end A and to the direction of the geometric past quantum jump by quantum jump so that the field pattern inside MEs would shift towards geometric past and effectively move with super-luminal velocity. This would imply effective super luminal group velocity for the classical fields inside ME and also for the pattern of coherent photons. In this case the effective super-luminal light velocity would be most naturally constant irrespective of the length of the narrowed region. This is not consistent with the experimental findings. Note that the variant of this mechanism for positive energy MEs could provide the space-time correlate for the reduction of light velocity in dielectrics.

Experiments believed to involve anomalous interference

The experiments of Cardone and coworkers [D13] stimulated my own interest in the super-luminal propagation, a possible breaking of LLI, and non-locality. The experiments of Cardone were motivated by the notion of hollow wave analogous to the notion of pilot wave of Bohm. Hollow wave would not carry energy but would represent a deformation of Minkowski metric and its interaction with photons would somehow induce anomalous interference effects.

1. The experimental arrangement

The experimental arrangement discussed in more detail [D13] (see **Fig. 9.1**) is following.

1. The geometry of the experimental arrangement can be described in terms of a configuration of vertical lines V_1, V_2 , and V_3 order from left to right and horizontal lines H_1, H_2, H_3 ordered from top to bottom. There are two identical sources S_1 and S_2 of IR photons, three identical slits F_1, F_2, F_3 and three identical detectors A, B, C (photodiodes sensitive to IR light).
 - i) S_2, F_3, C was in the intersection of $V_i, i = 1, 2, 3$ with the line H_3 in this order. C was in front of F_3 and detected photons from S_2 .
 - ii) F_2, B was at the intersection of $V_i, i = 2, 3$ with H_2 in this order.
 - iii) S_1, F_1 and A was at the intersection of $V_i, i = 1, 2, 3$ with H_1 in this order. The vertical line V_3 containing the detectors A and B could be moved in horizontal direction to five different positions.
2. F_2 was outside the cone of maximal intensity for the radiation from S_1 and in geometric optics approximation no photons was predicted to go through F_2 . The expectation was however that the “hollow waves” accompanying photons emitted by S_2 could propagate through F_2 and induce anomalous interference effects.
3. The geometric arrangement was such that B was predicted to detect nothing in the geometric optics approximation and this was found to be the case. Detector A was expected to detect only photons from S_1 : indeed, when S_1 was off and S_2 on, no signal was detected.

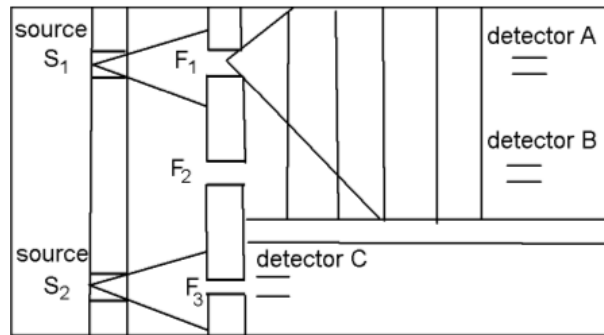


Figure 9.1: Schematic representation of the experimental arrangement of Cardone and collaborators.

2. Findings

Standard Maxwell's theory would predict that detector A should give same signal in the following situations:

- i) S_1 on and S_2 off
- ii) S_1 on and S_2 on.

What was found that when the distance d of the detector A from S_1 (on the same line parallel to x-axis) satisfied $d < 4$ cm, the two situations were different. The energy threshold defined as the difference of voltages in the detector A in situation i) and ii) was $\Delta_A(1 - 3) = 2.3 \mu V$ for $d < 4$ cm. The proposed interpretation was in terms of anomalous interference effects caused by "hollow waves" accompanying photons and diffracting through the slit F_2 .

3. TGD based model of remote metabolism as explanation of the effects

The general model of remote metabolism would look like follows.

1. The basic building blocks are negative and positive energy MEs containing phase conjugate IR photons. Although not separately mentioned in [D13], there are reasons to believe that the presence of the slit F_2 is necessary for the effect to occur. The interpretation would be that the standing microwave space-time sheet diffracts through F_2 . Also negative energy IR photons would tunnel through F_2 . Previous considerations allow to consider the possibility that hollow waves correspond to space-time sheets with an Euclidian signature of the induced metric so that physics itself would provide description of the situation with length scale resolution of the order of beam width. What is highly interesting that the critical distance d corresponds to the p-adic length scale $L(k) = 2^{(k-151)/2} L(151)$, $L(151) = 10$ nm for $k = 195$.
2. In order to develop the model further, a rough picture about the functioning of the detector A is necessary. When a photon is detected by A , it creates an electron hole pair in the active region of the photodiode. Conduction electron starts to move towards the n layer of the diode (catode) whereas hole moves towards the p layer (anode).
3. Detector A emits negative energy phase conjugate IR photons absorbed by S_2 . The emission of negative energy photon from A means that electron becomes a conduction electron so that electron-hole pair is generated and a positive contribution to the voltage of the photodiode is generated. The absorption of photon by S_2 induce a transition of some atomic system in S_2 to a lower energy state without an emission of positive energy IR photon.
4. The "energy threshold" characterizes how efficiently photodiode at A generates negative energy photons and how effectively they are absorbed by S_2 and is a property of photodiode and photon source rather than of possible exotic interactions such as anomalous interference.
5. The model makes several predictions. Negative energy photons can be absorbed when their energies are sub-thermal so that mechanism might not work for photons with sub-thermal energies. The prediction is that the presence of the detector C is not necessary for the mechanism to work. The number of photons detected by the C should be changed by the negative of the amount that the energy detected by A is changed.

The experiments involving crossed photon beams

In [D13] the privately communicated preliminary experimental results of Ranfagni and coworkers are analyzed. The experimental arrangement is illustrated in figure ???. The primary microwave photon beam A_1 generated by a microwave antenna antenna splits into two beams A_{11} and A_2 . A_{11} is amplified by a second microwave antenna. A_2 , the secondary beam, propagates inside a waveguide, is modulated at 1500 Hz frequency by a chopper and passes to the detector. Either A_1 or A_2 is attenuated.

A_{11} and A_2 cross each other orthogonally and apart from very small interference predicted by QED (photon photon scattering), the effect of A_{11} to the detector should vanish.

1. Findings

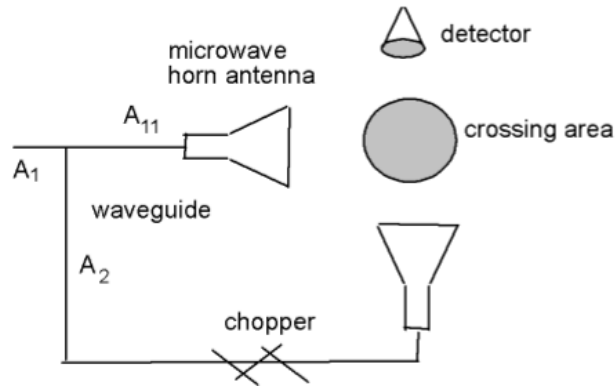


Figure 9.2: Schematic representation of the experimental arrangement of Ranfagni and collaborators discussed in [D13].

The experiment demonstrates that the signal generated by photons in detector A depends on whether A_1 or A_2 is attenuated. The experimenters interpret the finding in terms of an anomalous interference involving “hollow waves”.

Figure 7 of [D13] depicts the voltage of detector A as function of attenuation and polarization for A_1 and A_2 attenuation. If A_2 is attenuated, the voltage of the photodiode as a function of attenuation stays positive. If A_1 is attenuated, signal changes sign somewhat below 10 dB but approaches in both cases asymptotic value of $5 \mu V$ above 30 dB if the size of the crossing beam region is less than 8-9 cm *resp.* 4 cm for microwave *resp.* IR photons. Asymptotic situation corresponds to a single photon condition. There is no detectable dependence on beam energy but photon polarization affects somewhat the situation.

The laser variant of the experiment performed by Meucci and coworkers uses IR light without modulation and a similar effect is detected.

2. An overview of the TGD based model

The picture behind the TGD based model is following.

1. The propagation of the microwave through a resistor in microwave circuit is the simplest manner to achieve attenuation. Electrons absorb the microwave energy and dissipate it. Attenuation is a process analogous to a detection since photon is absorbed also now.
2. There is a competition between detector D and attenuator A about energy. In the case of A_2 attenuation D wins and sucks more energy from A_2 than A_2 from D : photodiode voltage is positive. For A_1 the situation is opposite in a critical range [8, 30] dB of attenuation strength A so that the voltage of the photodiode becomes negative. Conduction electrons in the photodiode annihilate with holes and a negative voltage contribution is generated. Asymptotically detector wins in both cases and this explains positive $5 \mu V$ voltage at large values of attenuation A .
3. Generalized four-wave interaction occurs most naturally in the detector and in the attenuator. Standing microwave space-time sheet and IR MEs with negative energy correspond to the four waves involved. The size of the region in which four wave interaction occurs is determined by the size of the crossing region. The wavelength and width of the standing waves between detector and attenuator corresponds to the critical length parameter L , which corresponds to a microwave wavelength in both variants of the experiment. Negative energy IR photons propagate between attenuator and detector along the wave guide A_2 . The branching of the A_1 induces also a branching of the beam of negative energy photons.
4. These length scales L corresponds to the p-adic length scale $L(197)$ for microwave photons and $L(195)$ for IR photons. This suggests that the microwave frequencies involve correspond

to p-adic length scales. p-Adic frequencies are indeed expected to define “miracle frequencies” in TGD Universe and I have already proposed that these frequencies and corresponding p-adic codes might be used by more advanced civilizations of the geometric future to communicate with the civilizations of the geometric past (including ourselves). What is interesting that the attenuation need not make possible this kind of communications since time reflection of the signal back from geometric past instead of time transmission does involve attenuation.

5. The catastrophe theoretic model is inspired by the general model for Searl effect based on remote metabolism. Qualitatively the model is characterized by the numbers of state and control parameters. The voltage of photodiode of the detector is in the role of the state variable so that cusp, swallowtail, and butterfly are the candidates for the elementary catastrophes involved. At least $V = 0$ and $V \neq 0$ at the one photon limit represent steady states so that cusp catastrophe and less probably, the dual of butterfly catastrophe having both two steady states provide a possible model of the situation. Note that butterfly reduces to cusp in subregion of the parameter space.

3. The identification of the control variables

Consider now the possible control variables.

1. The attenuation of the beam A_1 or A_2 , denote it by A , is certainly a relevant dimensionless control parameter. From figure 7 of [D13] one finds that the sign of V changes rapidly as a function of attenuation A below 10 dB and stays negative in certain range of values of A for F_1 attenuation. For A_2 attenuation V preserves its sign. This suggests an idealization in terms of a discontinuous dropping from the upper sheet of cusp to the lower sheet so that A would be identifiable as the normal factor of the cusp.
2. The index $i = 1, 2$ telling whether the primary or secondary beam is attenuated is also a natural control variable. The naïve expectation is that some fraction of the beam of negative energy photons from A_1 leaks out when the secondary beam branches from A_1 . It however turns out that “time refraction” in which negative energy signal is amplified in the branching must occur in order to explain the experimental findings.
3. The dimensional control parameters are following.
 - (a) The width L of the beam is certainly a control parameter and determines the size of the crossing region, which as such has no relevance in TGD framework since anomalous interference is not assumed to be the underlying mechanism. The wavelength $\lambda = c/f$ of the photon beam is second candidate for a control parameter. The distance d from the detector to the attenuator also distinguishes between A_1 and A_2 attenuation. Together with the attenuation strength A this would make four control variables. The overall size of the system, call it X , is a further control variable which can be however eliminated if scaling invariance holds true by taking X as a length unit.
 - (b) The critical value of L is reported to be the same for $d = d_1$ and d_2 . When L is below the critical value L_{cr} a steady state $V \neq 0$ becomes possible. Below it $V \rightarrow 0$ corresponds to the steady state at the one-photon limit. Hence L plays the role of the splitting factor of cusp catastrophe. The critical value of L for IR photons and microwave photons differs by a factor of order two (change of p-adic miracle wavelength) so that there is a weak dependence on the wavelength and λ acts as a non-trivial control parameter. In the first approximation one can forget λ as an active control variable.
 - (c) The variable d representing distance between attenuator and detector is a candidate for a further control variable. The experiments do not allow to decide whether d is a relevant control variable.

The minimum option is based on the identification of A , L , and discrete variable i as control variables.

4. *A more detailed specification of the catastrophe theoretic model*

The equation for the charge of the photodiode modelled as a capacitor reads as

$$\begin{aligned} \frac{dQ}{dt} &= C(V) \frac{dV}{dt} \\ &= I_B(A) + I_D(V, A, L, \lambda) - I_A(A, i, L, \lambda) \equiv F(V, A, L, i, \lambda) . \end{aligned} \quad (9.6.14)$$

Here $I_B(A)$ denotes the contribution of the beam of photons. In the absence of new physics it would be the only term at the right hand side. I_B is obviously proportional to A :

$$I_B(A) = A \times I_B(A = 1) ,$$

and thus decreases with attenuation. I_D corresponds to the current due to the spontaneous generation of negative energy photons by detector and received by attenuator. I_A is the corresponding current induced by the attenuator competing with the detector about energy resources. The first guess is that A_1 and A_2 differ in the sense that part of the beam of the negative energy photons from attenuator A_1 can split into two beams: hence the functional form of I_A is different for $i = 1$ and $i = 2$.

The asymptotic steady states satisfy

$$\frac{dQ}{dt} = F(V) = 0 . \quad (9.6.15)$$

This gives an expression of V as a zero of the function appearing at the right hand side. The dependence of C on V does not matter in the adiabatic situation. Since there is only one state variable involved, one can always write the right hand sided $F(V)$ as a gradient of a potential function Φ :

$$F(V) = \frac{d\Phi}{dV} , \quad (9.6.16)$$

so that catastrophe theory applies and irrespective of the form of potential the situation is diffeomorphic with a butterfly catastrophe with additional discrete control variable i and expected to reduce to cusp catastrophe in the range of control variables studied in the experiments.

From the behavior of V as a function of A one can deduce the following.

1. If d would appear as an argument of I_D asymptotics would not be the same for $d = d_1$ and $d = d_2$ unless one has $I_D(d_1) \simeq I_D(d_2)$ for large values of A . Hence it seems that I_D does not depend on d . The dependence of $I_A(A, i, \dots)$ on i is reflected in the difference of the graphs of $V = f_{A_i}(A)$, $i = 1, 2$ as function of attenuation.
2. I_A must be negligible at the limit $A \rightarrow 0$ of high attenuation since the asymptotic value of V does not depend on whether A_1 or A_2 is attenuated. Too strong an attenuation would mean that the attenuator is not anymore able to emit appreciably negative energy photons. $I_A \propto A(1 - A)$ is the first guess for I_A . For 30 dB attenuation one would have $A = 10^{-3}$ so that I_A would be indeed small.

In principle the model based on the emission of negative energy photons is able to reproduce the observed behavior for V . $I_B \propto A$ decreases as the attenuation increases whereas the current I_A induced by the generation of negative energy photons from the attenuator increases when the attenuation parameter increases since the probability for generation of negative energy photons is expected to grow with the size of attenuator and thus with $1 - A$. Thus the observed change of sign of V for A_1 attenuation can occur for

$$\begin{aligned} I_D(A, \dots) &< I_A(A, i = 1, \dots) , \\ I_B(A) &< I_A(A, i = 1) . \end{aligned} \quad (9.6.17)$$

The condition

$$I_A(A, 1) > I_A(A, 2) \quad (9.6.18)$$

must be satisfied and could relate to the branching of the primary beam and less probably with the value of the parameter d . This condition is not consistent with the expectation that $I_A(A, 1)$ is a fraction of $I_A(A, 2)$. Branching should induce an amplification of the negative energy signal. This would suggest that the branching corresponds to a “time refraction” in which the refracted part of the signal corresponds to positive energy photons.

Chapter 10

About Concrete Realization of Remote Metabolism

10.1 Introduction

The idea of “remote metabolism” (or quantum credit card, as I have also called it) emerged more than a decade ago - and zero energy ontology (ZEO) provides the justification for it. The idea is that the system needing energy sends negative energy to a system able to receive the negative energy and make a transition to a lower energy state. This kind of mechanism would be ideal for biology, where rapid reactions to a changing environment are essential for survival. Originally this article was intended to summarize a more detailed model of remote metabolism but the article expanded to a considerably more detailed view about TGD inspired biology than the earlier vision.

10.1.1 Short Glossary About The Basic Concepts Of TGD

The model involves several new physics elements. It is good to begin with a little glossary to get a rough view about basic ideas of TGD and TGD inspired biology. The following list explains briefly the notions relevant to the ontology of TGD Universe.

- The notion of *many-sheeted space-time* (see **Fig.** <http://tgdtheory.fi/appfigures/manysheeted.jpg> or **Fig.** 9 in the appendix of this book) distinguishes between TGD and special and general relativities. In TGD framework space-times are regarded as 4-D surfaces in certain 8-D space $M^4 \times CP_2$ obtained from empty Minkowski space M^4 by adding four small dimensions. The study of field equations characterizing space-time surfaces as “orbits” of 3-surfaces (3-D generalization of strings) forces the conclusion that the topology of space-time is non-trivial in all length scales. Many-sheeted space-time consists of space-time sheets in various length scales with smaller sheet being glued to the larger ones by wormhole contacts (see **Fig.** <http://tgdtheory.fi/appfigures/wormholecontact.jpg> or **Fig.** ?? in the appendix of this book) identified as building bricks of elementary particles. The sizes of wormhole contacts vary but are at least about CP_2 size (about 10^4 Planck lengths) and thus extremely small for ordinary elementary particles.
- The notion of many-sheeted space-time forces the replacement of reductionism with *fractality*. This is the basic motivation for applying TGD in, say, biology. The most radical prediction is the existence of scaled variants of physics of strong and weak interactions in various length scales, and biology is especially interesting in this respect. Fractality reflects itself as various length scale hierarchies.
 1. *p-Adic physics* as a physics of cognition and intention and the fusion of p-adic physics with real number based physics are new elements. p-Adic mass calculations lead to the *p-adic length scale hypothesis* stating that preferred p-adic length scales correspond to primes p near powers of two: $p \simeq 2^k$, k positive integer. Mersenne primes M_k of form $2^k - 1$, and Gaussian Mersennes $M_{k,G}$ of form $(1 + i)^k - 1$ (k some

prime in both cases) are especially favored with biologically interesting length scale range [10 nm, 2.5 μ m] containing as many as four electron Compton scales assignable to Gaussian Mersennes, which could be seen as a number theoretic miracle.

2. **Dark matter hierarchy** realized in terms of a hierarchy of values of effective Planck constant as integers using \hbar as a unit. Large value of \hbar_{eff} makes possible macroscopic quantum coherence crucial in living matter. For instance, it allows dark ELF photons with energies above thermal energy ($E = \hbar_{eff}f$).

- **Topological field quantization** . This distinguishes between TGD and Maxwell's electrodynamics. TGD leads to a geometrization of the notion of classical field. Both weak, electromagnetic, and gluon fields are known once the space-time surface as a solution of field equations is known. This implies an enormous reduction in the number of degrees of freedom but the many-sheeted space-time brings in additional degrees of freedom allowing to avoid conflicts with known experimental facts about fields.

Topological field quantization means that fields are replaced by quanta of space-time. For instance, constant magnetic field decomposes into space-time surfaces of finite size representing flux tubes or sheets. Field configurations are like Bohr orbits carrying very specific "archetypal" field patterns. Radiation fields corresponds to so called topological light rays or massless extremals (MEs), magnetic fields correspond to magnetic flux quanta (flux tubes and sheets) having as primordial representatives "cosmic strings", electric fields correspond to electric flux quanta (say cell membrane), and elementary particles have so called CP_2 type vacuum extremals as basic building bricks.

- **Field body and magnetic body** . These notions follow from topological field quantization. In TGD Universe a physical system has a corresponding field identity - field body or magnetic body - in the sense that a given topological field quantum corresponds to a particular source (or several of them - say in the case of flux tube connecting two systems). In Maxwell's electrodynamics one cannot achieve this kind of identification since the fields created by different sources superpose. Superposition is replaced with a set theoretic union implying that only the *effects* of the fields assignable to different sources on test particle superpose.

Field body and magnetic body bring in new degrees of freedom highly relevant in TGD inspired quantum biology. Magnetic body has hierarchical onion-like structure reflecting corresponding structure for the system with which it is associated. One can also speak of **dark magnetic body** corresponding to the value of effective Planck constant $\hbar_{eff}/\hbar = n$. Dark space-time surface can be regarded as an analog of n -sheeted Riemann surface - an n -furcation of space-time surface occurring because of the extremely non-linear dynamics of Kähler action.

- **Magnetic body as an intentional agent using biological body as a sensory receptor and motor instrument** is an attractive identification but one should be cautious. One could argue that magnetic body and biological body together form the natural intentional unit - kind of "super-body" - and that in remote metabolism energy is transferred between biological and magnetic body parts. Note however that personal magnetic body has a hierarchical onion-like layered structure and that several magnetic bodies can use the same biological body making possible remote mental interactions such as hypnosis [L20].
- **Magnetic flux tubes and sheets** serve as "body parts" of the magnetic body, and one can speak about magnetic motor actions. Besides concrete motion of flux quanta analogous to ordinary motor activity, basic motor motor actions include the contraction of magnetic flux tubes by a phase transition reducing Planck constant, and the change in thickness of the magnetic flux tube changing the value of magnetic field and thus the cyclotron frequency. Reconnections of the flux tubes allow to magnetic bodies to get in contact and temporal variations of magnetic fields inducing motor actions of magnetic bodies favor the formation of reconnections. Flux tube connections at molecular level bring a completely new element to biochemistry. Flux tube connection serves as a space-time correlate for attention in TGD inspired theory of consciousness. ATP-ADP process could have interpretation in terms of reconnection.

- **Cyclotron Bose-Einstein condensates** of various charged particles can accompany magnetic bodies. Cyclotron energy $E_c = \hbar ZeB/m$ is much below thermal energy at physiological temperatures and magnetic fields possible in living matter. In the transition $\hbar \rightarrow \hbar_{eff}$ E_c is scaled up by a factor $\hbar_{eff}/\hbar = n$ and for sufficiently high value of \hbar_{eff} cyclotron energy can be above thermal energy $E = \hbar_{eff} ZeB/m$. The observations of Blackman about quantum like effects of radiation at harmonic of Ca^{++} cyclotron frequency could be used as motivation for introducing the hierarchy of Planck constants. The proposal is that cyclotron Bose-Einstein condensates associated with DNA and cell membrane - perhaps cell membrane proteins - play a key role in biology.
- **Massless extremals (MEs)/topological light rays** are extremals of the Kähler action replacing radiation fields in Maxwell's theory. Laser beam serves as a good analogy for ME. MEs are tubular space-time surfaces carrying classical fields propagating with light velocity. Since the waves propagate in single direction only there is no dispersion and MEs make possible precisely targeted communications without loss of information. Linear superposition is possible in the direction of ME. Both electromagnetic, weak, color and gravitational fields are present as induced fields. MEs can carry light-like currents and can be charged: in Maxwell's theory this is not possible. For charged MEs polarization has a longitudinal component. Tesla's scalar waves are obvious analogs for charged MEs. Charged MEs can however serve as correlates also for charged particles like electron.
- **Josephson junctions** are junctions between two super-conductors, say, parallel wires or analogs of capacitor plates carrying supra currents. **Josephson current** is generated when there is a phase difference $\Delta\Phi(t) = \int ZeV dt/\hbar$ between the two super-conductors involved. Josephson current is of the form $J = J_0 \sin(\Delta\Phi(t))$. For constant voltage V the current is oscillating with **Josephson frequency** $f_J = ZeV/\hbar$. The frequency for cell membrane is rather high for the ordinary value of Planck constant but $\hbar \rightarrow \hbar_{eff}$ scales it down so that even ELF frequencies are possible. The charge carriers of Josephson current are in accelerated motion and expected to radiate. The radiation is quantum process analogous to emission of photon by an atom and occurs with quantized energies coming as harmonics of Josephson energy ZeV having interpretation as electrostatic energy gained by the charge carrier "freely falling" through the junction. Charged particle can jump to the other side of cell membrane by absorbing positive energy Josephson photon or sending negative energy Josephson photon. This would define the basic mechanism of charge transfer for ionic pumps.

In TGD inspired biology Josephson junctions are associated with electric flux quanta of which cell membrane carrying extremely strong electric field represents the basic example. In low length scale resolution one can regard the entire cell membrane as a Josephson junction. In improved length scale resolution cell membrane proteins are natural candidates for Josephson junctions and might define quantum counterparts for channels and pumps. The conjecture is that superconductors and Josephson junctions form a length scale hierarchy. The levels of this hierarchy can communicate by exchange of Josephson photons if the values of \hbar_{eff} and Josephson energies were the same for them.

- The recent view about **negentropic entanglement** forced by Negentropy Maximization Principle (NMP) [K73] is very simple and leads to a connection between negentropic entanglement (see **Fig.** <http://tgdtheory.fi/appfigures/cat.jpg> or **Fig. ??** in the appendix of this book), dark matter hierarchy, p-adic physics, and quantum criticality. NMP holds true only in the intersection of realities and p-adicities - that is, applies in the situations in which density matrix for a system and its complement is multiple of identity matrix resulting in general quantum measurement identified as a measurement of the density matrix. Negentropic entanglement is always maximal entanglement so that the density matrix is proportional to unit matrix and corresponds to a value of effective Planck constant equal to the integer $\hbar_{eff} = n\hbar$ telling the number of the entangled states. The p-adic prime assignable to the system corresponds to the largest prime power factor of n . n has interpretation as the number of sheets of multi-sheeted covering defining n -furcation of space-time sheet and the n -furcation is manifestation of quantum criticality implying n -sheeted covering property. Negentropic entanglement is a prerequisite for an experience defining abstraction as a rule having as instances the state pairs appearing in the entangled state. Note that the state

pairs are not unique since any unitary transformation acting in the same manner to the two entangled state basis is allowed.

- In **zero energy ontology** (ZEO) physical states are pairs of positive and negative energy parts having opposite net quantum numbers and identifiable as counterparts of initial and final states of physical event in ordinary positive energy ontology. Positive and negative energy parts of the zero energy state are at the opposite boundaries of **causal diamond** (CD) defined as a double-pyramid-like intersection of future and past directed light-cones of Minkowski space.

There is a fractal hierarchy of CDs within CDs (and perhaps also overlapping with each other). The sizes of CDs (definable by the temporal distance between its tips) come as integer multiples of CP_2 time T_{CP_2} and the fundamental time scale $T = .1$ s of biology corresponds to $T = nT_{CP_2}$, $n = M_{127} = 2^{127} - 1$. This time scale corresponds to the secondary p-adic time scale assignable to electron and is macroscopic. As a matter of fact, all elementary particles correspond to macroscopic time scales: this predicts a direct connection between elementary particle physics and macroscopic physics.

In TGD inspired theory of consciousness CD defines what might be called a spot-light of consciousness in the sense that the contents of conscious experiences associated with given CD are about the space-time sheets in the embedding space region spanned by CD. Physical states are superpositions of pairs of positive and negative energy parts at opposite boundaries of causal diamond (CD) defined as double-pyramid-like intersection of future and past directed light-cones of Minkowski space. The conserved quantum numbers of positive and negative energy parts are opposite. Zero energy state is actually a superposition of zero energy states associated with CDs of different size scale characterized by integer. Time evolution with respect to subjective time is a sequence of state function reductions at opposite boundaries of CDs involving localization of that boundary and state function reduction at it but necessarily forcing the de-localization of the opposite boundary. During this process CDs in the superposition tend to increase in size, and this gives rise to the experienced flow and arrow of time. The pairs of state reductions at opposite boundaries correspond to sensory percept followed by motor action as reaction at the level of the brain. Phase conjugate laser beam would represent a standard example of negative energy photons.

Negative energy signals would have several functions: realization of intentional action initiating neural activity in geometric past would explain Libet's well-known findings, memory as communication with geometric past with time reflection in time direction defining "seeing" in time direction, and remote metabolism.

10.1.2 Plan of the chapter

The model of remote metabolism and the vision behind it is applied to biology. It is shown that the basic notions of the theory of Ling about cell metabolism inspired by various anomalies have natural counterparts in TGD based model relying on the notion of magnetic body. Remote metabolism can be considered as a universal mechanism of metabolism with magnetic body of ATP, or system containing it, carrying the metabolic energy required by the biological user. In particular, the role of ATP is discussed in Ling's theory and from the point of view of TGD-inspired theory of consciousness.

It is easy to imagine new technologies relying on negative energy signals propagating to the geometric past and ZEO justifies these speculations. Remote metabolism could make possible a new kind of energy technology. The discoveries of Tesla made more than a century ago plus various free energy anomalies provide excellent material for developing these ideas, and one ends up with a concrete proposal for how dark photons and dark matter could be produced in capacitor-like systems analogous to cell membranes and acting as Josephson junctions and how energy could be extracted from "large" magnetic bodies.

The model identifies Josephson frequency with the subharmonic of the frequency characterizing the periodicity of a periodic voltage perturbation assumed to correspond to cyclotron frequency in biological applications. Together with quantization conditions for charge and effective Planck constant it leads to precise quantitative predictions for capacitor-like systems acting

as dark capacitors. Also a relationship between the magnetic field at magnetic body of the system and the voltage of the capacitor-like Josephson junction emerges.

The predictions allow new quantitative insights about biological evolution as emergence of Josephson junctions realized as capacitor-like systems both at the level of cell, DNA and proteins, and brain. \hbar_{eff} can be related to Josephson frequency and cyclotron frequency and thus to measurable parameters. \hbar_{eff} serves as a kind of intelligence quotient and its maximization requires the maximization of both the voltage and area of the membrane-like capacitor system involved. This is what has happened during evolution. Indeed, the internal cell membranes, cortical layers and DNA double strand in chromosomes are strongly folded, and the value of membrane electric field is roughly twice the value of the electric field for which di-electric breakdown occurs in air. Even 40 Hz thalamocortical resonance frequency can be understood in the framework of the model.

The claimed properties of Tesla's "cold electricity" suggest interpretation in terms of dark matter in TGD sense. This leads to a proposal that a transition to dark phase occurs when the value of voltage equals the rest mass of charged particle involved. This criterion generalizes to the case of cell membrane and relates the values of \hbar_{eff} , p-adic prime p , and threshold potential for various charged particles to each other. The idea that nerve pulse corresponds to the breakdown of super-conductivity as a transition from dark to ordinary phase receives additional support. The resulting picture conforms surprisingly well with the earlier speculations involving dark matter and p-adically scaled variants of weak and color interactions in biologically relevant length scales. An extremely simple mechanism producing ATP involving only the kicking of two protonic Cooper pairs through the cell membrane by Josephson photon as a basic step is proposed. Also the proposal that neutrino Cooper pairs making sense in TGD framework but not in standard model could be highly relevant not only for cognition but also metabolism finds support.

The appendix of the book gives a summary about basic concepts of TGD with illustrations. Pdf representation of same files serving as a kind of glossary can be found at <http://tgdtheory.fi/tgdglossary.pdf> [L21].

10.2 Quantum credit card

The receiving system serving as energy storage would be analogous to a population reversed laser and one can imagine at least two new physics options for the laser like system.

10.2.1 Two realizations for the "population inverted laser"

The two options could be realized for ordinary matter at biological body and for dark matter at the magnetic body respectively.

1. One possibility is provided by zero point kinetic energy depending on the size scale of the space-time sheets $E \sim \hbar^2 \pi^2 / 2mL^2(k)$, where $L(k)$ is the p-adic length scale given by p-adic length scale hypothesis stating that p-adic primes $p \simeq 2^k$, k integer are favored. m refers to the mass of the particle transferred between space-time sheets as the laser like system is excited or de-excited. I have considered the identification for a hierarchy of metabolic energy quanta in terms of p-adic length scales coming as square roots of powers of two and defining a hierarchy transition energies which are not identifiable as ordinary molecular transition energies [K13]. The ordinary metabolic energy quantum whose nominal value can be taken as .5 eV belongs to this hierarchy and corresponds to proton for atomic p-adic length scale $L(139)$ or to electron Cooper pair with p-adic length scale $L(149)$. From $m_p/2m_e \simeq 2^{10}$ and from the ratio of p-adic mass scales $2^{(149-139)/2} = 2^5$ it follows that zero point kinetic energies are approximately the same. This option makes sense for visible matter and also for dark matter: the zero point kinetic energies are same since $L(k, \hbar_{eff}) = (\hbar_{eff}/\hbar)L(k, \hbar)$ is very natural assumption. $\hbar_{eff} = n\hbar$ is the effective value of Planck constant. This hierarchy most naturally holds true for ordinary matter and I have discussed unidentified spectral lines from outer space as a possible evidence for the existence of this hierarchy.
2. Second option would be natural in dark matter sector for dark matter residing at the magnetic body of a given system serving as the energy storage of the system. The cyclotron Bose-Einstein condensates of bosonic ions or Cooper pairs of fermionic ions would define the

analog of population reversed laser. TGD inspired nuclear physics allows also to have bosonic counterparts of fermionic ions behaving chemically in the same manner as their fermionic counterparts [L3]. The excitation energy would be defined by cyclotron energy $E = \hbar_{eff} f_c$, $f_c = qB/4\pi m$: here q and m are the charge and mass of the charged particle in question. If the value of \hbar_{eff} is large enough, cyclotron energies are above thermal energy. For ordinary value of Planck constant they are typically very small.

The realization of quantum credit card for the latter option relies on reconnection of the magnetic flux tubes of the system extracting the energy and those associated with the energy storage. The energy storage could be higher onion-like layer of the personal magnetic body of the system or even some other magnetic body. The reconnection is possible only if the magnetic field strengths of reconnecting flux tubes are identical. Therefore the system needing energy should be able to tune the field strength on the receiving flux tubes by varying their thickness (conservation of magnetic flux guarantees that field strength behaves as inverse of the cross-sectional area of the flux tube). The reconnection gives rise to a formation of a flux tube between two systems and the system needing energy can send negative energy received by the excited cyclotron BE condensate.

This mechanism can also be behind the binding of molecules to corresponding receptors allowing the molecule to recognize the presence of the receptor after which the contraction of the flux tube by a phase transition reducing \hbar_{eff} would bring the molecule to the receptor. Also water memory and homeopathic healing - and also immune system - would rely on the same mechanism. This mechanism appears also in the model of hypnosis as a kind of hijacking of parts of brain of the subject by hypnotist and in the general model of remote mental interactions.

10.2.2 Support for quantum credit card mechanism

There is some empirical support for the credit card mechanism.

1. Photons of phase conjugate laser light behaves like negative energy photons in the sense that second law holds true in the reversed direction of geometric time which must be distinguished from experienced time.
2. Popp has identified a process equivalent to "sucking of energy" in living matter, interpreting it as an extraction of energy in the form of bio-photons [?]. Extraction mechanism allows interpretation in terms of sending of negative energy photons, which can also be dark. In TGD Universe bio-photons would result as dark photons decay in energy conserving manner to ordinary photons [K17]. The decay rate could be very small so that the intensity of dark photons could be quite high.
3. Sleightdogs (see <http://tinyurl.com/zg9j3p9>) [I69] can run for several days without eating and no signatures of ordinary metabolism have been found. This phenomenon cannot of course be specific to sleigh dogs. Remote metabolism could explain the phenomenon as an extraction of metabolic energy from non-standard sources in absence of standard sources - say from the magnetic body associated with the collective formed by the dogs.
4. Yan Xin Qigong practitioners report that in so called Bigu state there is no need to eat solid food at all for days, weeks, months or even years. Western science is beginning to take Bigu state (<http://tinyurl.com/y7unnww4>) seriously [I42] and the first national conference on Bigu state was held at the Pennsylvania State University in 2000, with presenters such as as Rustum Roy, founding director of Penn State's Materials Research Laboratory and Hans Peter Duerr, former director of the Max Planck Institute.

One could argue that these individuals live by utilizing dark light as metabolic energy. Does living matter use quantum credit routinely or only in special situations when ATP-ADP mechanism is not available or the neural processing of incoming information leading to the decision about motor action is too slow? Quantum credit card mechanism allows also to initiate the neural activities preceding motor action in the geometric past and Libet's experiments indeed give support for this. Intentional action could be also seen as a top-down process in reverse time direction in which neural activity would be the last step.

One could also raise a more heretical question: could metabolic energy be always received by quantum credit card mechanism? Could the mysterious "high energy phosphate bond" actually reflect the fact that the metabolic energy is extracted from the magnetic body of ATP or some system containing it? Could energy reservoirs be filled by sending dark photon radiation exciting cyclotron states (EEG would be only one example of dark photons)? Or could $\text{ATP} \rightarrow \text{ADP}$ fill energy reservoirs at magnetic body?

The best manner to test this is by studying cells under metabolic deprivation. Ling [I130] has argued that ionic pumps and channels do not actually exist and the experimental support for this was his experimental finding that cells continue to function under metabolic deprivation. This could be also interpreted as support for the hypothesis that the ionic currents flowing through cell membrane are supra currents so that dissipation is very low and pumping is un-necessary. My own argument [K24] runs as follows:

"One can also wonder how metabolism is able to provide the needed energy to this continual construction of pumps and channels and also do the pumping. For instance, sodium pump alone is estimated to take 45-50 per cent of the cell's metabolic energy supply. Ling has studied the viability of the notion of the ionic pump experimentally [I130] by exposing cell to a cocktail of metabolic poisons and depriving it from oxygen: this should stop the metabolic activities of the cell and also stop the pumping. Rather remarkably, nothing happened to the concentration gradients! Presumably this is also the case for the membrane potential, so that the notion of metabolically driven electrostatic pumps seems to fail. Of course, some metabolism is needed to keep the equilibrium but the mechanism does not seem to be a molecular mechanism and somehow manages to use extremely small amount of metabolic energy."

My proposal has been that pumps and channels can be there, but are needed basically for the purpose of taking samples about the state of the cellular environment. This view was inspired by the vision that cell membranes serve as sensors communicating information about the cellular environment to the magnetic body. Metabolic energy is however needed for other purposes and one might argue that the finding of Ling supports the view that a cell in this kind of situation uses quantum credit card to extract energy from some magnetic body.

10.2.3 Gut cells without mitochondria can survive: proof for the notion of remote metabolism?

Gut cells can survive without mitochondria (see <http://tinyurl.com/hqq79th>)! There are many other strange findings. Visible and IR light energize human skin cells transferring energy for the cells- the analog of photosynthesis. Some spiritual groups and also traditionally the people called saints are reported to survive by using only sunlight as their source of metabolic energy. NASA has studied sleigh dogs able to run for days without eating and showing no signs of getting tired.

Could photosynthesis work also in animal mitochondrial cells? The basic mechanism could be essentially the same: electron transfer chain providing energy to pump protons through cell membrane against potential gradient. This is the key step of both photosynthesis and cellular respiration. After that protons flow spontaneously back through ATP synthase and liberate energy to build ATP from ADP. This is like power plant. In plants solar photons provide the energy for electrons. In the animal cells dark photons with large $h_{eff} = n \times h$ (transforming now and then to biophotons) could do it. In the case of IR lmetabolism electrons could send to the energy source dark negative energy IR photons, which decay to ordinary IR photons. This would be an active variant of metabolism and time reversal of the usual mechanism: I have called it quantum credit card mechanism or remote metabolism [L44].

Now even mitochondria are missing! Could remote metabolism work also without mitochondria? $\text{ADP} \rightarrow \text{ATP}$ transformation should occur since ATP is the universal energy currency. Could it take place as remote metabolism by sending negative energy photons to the cells having the mitochondria. The electron transfer chain is preceded by Krebs cycle extracting the energy from nutrients: could the absorption of negative energy photons induce the decay of nutrient without transfer of energy to electron chain of the mitochondria. The hungry gut cell without mitochondria would be allowed to eat in the table of the luckier ones. Again one quantum objection against

vulgar darwinism. This would be like kicking laser from population reversed state to ground state by phase conjugate negative energy irradiation.

10.3 Confirmation of Santilli's detection of antimatter galaxies via a telescope with concave lenses:really?

I encountered in Facebook a really bizarre sounding title reading *The incredible pictures scientists say prove invisible alien entities ARE here on Earth* (see <http://tinyurl.com/hvsqbhj>) and just for curiosity decided to add one click to the web page in question (means higher income from ads) knowing that this is just what they want me to do! The story involves aliens spying us so that the street credibility index of the story reduced zero. The tool to detect the spies would be Santilli's telescope using concave lenses. Santilli, who is familiar to me, also talks about two types of invisible terrestrials detected by his telescope. It would be easy to ridicule but let us be patient.

An earlier article with title *Apparent detection of antimatter galaxies via a telescope with convex lenses* [H17] (see <http://tinyurl.com/hmkhml6>) reports a detection of antimatter galaxies. There is also an article with title "Confirmation of Santilli's detection of antimatter galaxies via a telescope with concave lenses" published in American Journal of Modern Physics [H5] claiming an independent observation of antimatter galaxies, antimatter asteroids, and antimatter cosmic rays by Santilli's telescope (see <http://tinyurl.com/hezdys2>). These articles say nothing about aliens spying us.

Since I suffer from a pathological trait of taking half-seriously even the weirdest stories, I decided to learn what Santilli's telescope using concave lenses might mean. Ordinary telescope uses convex lenses (see <http://tinyurl.com/oqfjsly>). The light rays coming from the other side converge to form a picture of the source. For concave lens the light rays coming from the other side diverge so that concave lens does not sound like a good idea for detecting light coming from distant objects.

It is however claimed that Santilli's telescope detects light sources in darkness. This is only possible if the index of refraction $n = c/v$ characterizing the medium via the ratio of light velocity in vacuum to the velocity of light in medium changes sign. From Snell's law $n_1 \sin(\theta_1) = n_2 \sin(\theta_2)$ follow the basic facts about lenses (see <http://tinyurl.com/ybpdwweo>). It is possible to construct lenses which have negative index of refraction so that concave lens behaves like convex one. Presumably this is not the case now since according to the existing theory, ordinary light would have the negative index of reflection (unless it is somehow transformed when arriving to the lens).

Concerning the theoretical arguments Santilli makes several claims, which do not make sense to me.

1. The photons are identified as antimatter photons assumed to have negative energies. These antimatter photons are assumed to have repulsive gravitational interaction with ordinary matter. The claim is that this implies negative index of refraction. This does not make sense since gravitational interaction is quite too weak to cause refraction. Electromagnetic interaction must be in question. Antimatter photons are claimed to propagate with superluminal speeds and arrive instantaneously from remote galaxies. The assumption is in dramatic conflict with what we know about antimatter.
2. Refractive index is claimed to be a property of light. This does not make sense: refractive index characterizes medium. Its sign however changes when the energy of photon changes sign. From Snell's law the sign of refractive index must change sign as the light enters to the concave lens. This would require that Santilli's antimatter photons transform to ordinary photons.

These arguments are more than enough for dooming the claims of Santilli as pseudoscience but what if there is something in it? The experimental finding is so simple that if it is not an artefact of poor experimentation, some interesting - possibly new - physics could be involved. So let us look the situation from different point of view forgetting the theory behind it and taking seriously the claimed observations. Could one explain the findings in TGD framework?

Zero energy ontology (ZEO) is one of the cornerstones of TGD and could indeed explain the claims of Santilli and colleagues. In ZEO zero energy states are pairs of positive and negative

energy states at opposite light-like boundaries of causal diamonds (CD) forming a scale hierarchy. Zero energy states are counterparts of physical events in standard ontology.

1. ZEO predicts that the arrow of time can have both directions. In ZEO based quantum measurement theory state function reductions occur at either boundary of CD. Conscious entities correspond to sequences of reductions leaving everything unaffected at the boundary (Zeno effect) but changing the situation at the opposite boundary, in particular increasing its distance from the fixed boundary, which gives rise to the experienced flow of time. The first reduction to opposite boundary replaces the zero energy state with time reversed one. This can happen also for photons.
2. The particles with non-standard arrow of time are not antimatter (I have considered also this possibility since it might explain the experimental absence of antimatter) but propagate in reverse time direction and have negative energies. There is a considerable evidence for this notion. Phase conjugate laser beams known to obey second law in reverse time direction would be one example. There are also old observations of Akimov and Kozyrev [H12, H7] claiming that the instrument of Akimov gives three images of distant astrophysical objects: one would be from past, one from recent, and one from future. I do not know about the construction of Kozyrev's instrument but one can ask whether it involved concave lenses. Also the notion of syntropy introduced by the Italian physicists Fantappie [J92] conforms with this picture. In biology syntropy is in central role since in biology time reversed radiation would play a key role.
3. Since the sign of the energy is negative for phase conjugate photons, their refractive index is negative. n_2 for concave lense and n_1 for the medium behind lense must have opposite signs to explain the claims of Santilli and colleagues. This happens if the incoming negative energy photons from the geometric future are transformed to positive energy photons at the surface of the lense. This process would represent time reflection of the incoming negative energy photons to ordinary positive energy photons propagating inside lense.

The claimed results could be an outcome of a bad experimentation. What however remains is a test of ZEO - or more precisely, the notion of time reversed photons - using telescopes with convex lenses. The implication would be possibility to see to the geometric future using telescopes with concave lenses! An entire geometric future of the Universe would be open to us! This possibility is a good enough reason for seeing the trouble of proving experimentally that Santilli is (and I am) wrong! Negative index of refraction as a function of frequency is a real phenomenon in condensed matter physics (see <http://tinyurl.com/ybpdwweo>), and one can of course ask whether also it involves the transformation of positive energy photons to negative energy photons.

10.4 Comparison Of Ling's Vision Of The Cell To TGD View

Gilbert Ling (<http://tinyurl.com/ycsbhejz>) has proposed a theory of cell and living systems which challenges some basic assumptions of standard cell biology [?, I130, I131, I132, I97, I123, I124]. This theory has several points of contact with the TGD view about living matter and it is interesting to compare the two approaches.

10.4.1 Ling's Basic Ideas And Concepts

Ling challenges the notions of ionic pumps and channels, the notion of high energy phosphate bond, and the prevailing view about the role of ATP as energy currency. Ling also questions the views about the role of water and lipid layers of cell membrane in biology. Reading Ling's article about mitochondria [I124] revealed to me how little is known about living matter and how primitive the theories really are. It is difficult to avoid the feeling that the biochemical approach is a heroic attempt to understand living matter without appropriate concepts and ideas and therefore doomed to lead to a vicious cycle of ad hoc hypotheses.

Ling's finding [I131] that a cell can survive for days under conditions of metabolic starvation is his basic argument in favor of the proposal that ionic pumps do not actually exist and that the transfer of various ions and molecules through cell membrane relies on different mechanisms.

Ling's theory [I130] is summarized in the article "Main principles of Ling's physical theory of the living cell" (<http://tinyurl.com/y7rz5twy>) by Vladimir Matveev [?]. Ling introduces several new notions.

1. *The notions of resting state and activated state .*

Biological basic structures in various scales appear in two states: resting state and activated state. These states are characterized by the associations between molecular pairs (to be described below). In the resting state most proteins are folded being covered with ordered water giving rise to several layers at the surface of the folded protein. Some protein however remain unfolded. In active state this layer melts and the protein's charged active sites become active and associations form between them and various ions or other active sites. Some proteins are unfolded also in the resting state. According to Ling ATP, water, and potassium ions (K^+) are adsorbed on the active sites of the unfolded proteins in resting state. In the activation ATP molecules are split and they give up phosphate ions to other molecules.

2. *Association between two molecules - call them A and B for definiteness .*

Association of B with A means that B tends to be adsorbed by A . Ling's argument [I130] goes as follows. Consider molecules A and B with opposite charges and assume that A is fixed in space (A could be protein and B ion). The fixing of the position reduces the kinetic energy and therefore reduces the total energy of the pair since Coulomb interaction energy is negative. Therefore the association of the molecules is energetically favored. An example of an associated pair would be protein and ion attaching to a charged active site of the protein, which is either anionic or cationic (negatively or positively charged). In this case one can indeed assume that the position of the protein is fixed.

3. *Selective adsorption of B by A .*

Adsorption probability described quantitatively in terms of affinity of A with respect to B - is enhanced by the presence of association so that one can speak of selective adsorption. Affinity of A with respect to B is defined as the energy liberated as B is attached to A . Electron affinity (<http://tinyurl.com/ycok9n4>) of atom is an especially important affinity. In Ling's theory affinities of various biomolecules or their functional groups with respect to water molecules, Na^+ and K^+ ions, and other functional groups appear as parameters. In particular, the affinities of C=O and N-H groups of the peptide bonds of proteins with respect to water molecules and other such groups are important. Also the affinities of COOH groups of the amino-acid residues containing two COOH groups with respect to Na^+ and K^+ ions are important.

Affinities characterize the state of the molecule: in particular, they are different for the resting state and activated state. For instance, unfolded proteins are highly affine with respect to K^+ in the resting state and with respect to Na^+ in the activated state. The phase transition changing the affinities accompanies the generation of action potential. The challenge is to understand why the affinities with respect to two ions with same charge and naïvely with same chemical properties are not essentially same. In principle, the definition of affinity as energy liberated in adsorption can explain this in terms of details of molecular chemistry since the geometry of the molecules matters besides charge distribution. The exponential dependence of Boltzmann factors appearing in equilibrium distributions could explain strong dependence of affinity on molecule.

The physical nature of selective adsorption - that is affinity - is assumed to depend on electron density in the functional group considered. Low electron density characterizes the resting state and high electron density the activated state. The main regulator of the electron density is ATP, which has electron acceptor properties (Ca^{++} , signal factors, hormones, and chemical modifications of proteins serve as regulators) In the resting state ATP adsorbed to the protein site displaces electron density to the adsorption site and when ATP is split,

the electron density is transferred to the activated state. This displaced electron density is analogous to "high energy phosphate bond".

4. *Adsorption of water* .

In Ling's theory the role of water [I97] differs from than in standard theory. The polypeptide backbone of any completely unfolded protein has a geometrically regular order of positive (N-H) and negative (C=O) charges of the dipoles. This geometry is complementary to the space between water molecules surrounding the protein. This complementary makes possible multilayer adsorption of water on the protein surface. Large fraction of the cellular water is transformed to an ordered water. The outcome are stronger dipole-dipole interactions (hydrogen bonds are the major contributors). As a consequence, the water layers become a poor solvent as compared to bulk water and solutes are displaced from the volume of the adsorbed water. Ordered water acts like an ice layer serving as a barrier against diffusion of large solute molecules. The ordered water at cell surface is assumed to explain cell's selective permeability.

As the cell is activated, the "ice layer" melts and diffusion into cell becomes possible and is not prevented by lipid layers. Also the selectivity of each functional group of polypeptide changes: instead of a high affinity with respect to water molecules one has a high affinity with respect to the functional groups of the back-bone. This gives rise to secondary structures of protein (such as alpha-helix).

5. *Induction process changing in a phase transition-like manner the associations between molecule pairs* .

Activation process is a thermodynamical phase transition. Ling uses as an analog system magnet, a roughly linearly ordered sequence of magnetizable nails, and iron powder. When the magnet is brought to the system, the first nail is magnetized and magnetizes the second nail, which in turn magnetized the third, ... The nails also attract that iron powder. The outcome is the organization of the system to a linear structure minimizing free energy. Skeptics can of course argue that this is just a metaphor involving in essential manner non-locality brought in by the presence of the long range magnetic field. Chemistry is however local and it is difficult to see how the non-locality could creep in without introducing some explicit realization for it. The problem is actually much more general: how it is possible that biomolecules manage to find their associates in the dense molecular crowd: how molecule *A* recognizes the presence of molecule *B* and how *A* and *B* then go to find each other to react chemically.

10.4.2 The Fundamentals Of Ling's Vision From TGD View Point

It came as a surprise that Ling's basic notions have rather direct TGD counterparts in terms of magnetic flux tubes and their dynamics based on reconnection and phase transitions changing the value of \hbar_{eff} inducing the change of flux tube length.

The new view about metabolism

More than 15 years ago I used [K13] Ling's finding [I131] related to the ability of the cell to survive under metabolic deprivation as an argument to support the hypothesis that ionic currents are supra currents running with low dissipation; in addition direct measurements support the quantal character of these currents identified as Josephson currents - in particular the fact that they do not depend on the properties of the membrane in question. Ling does not assume channels and pumps [I123], although in TGD framework they could be present. My cautious proposal has been that they exist for the purpose of taking samples about the molecular environment generating chemical sensory data communicated to the appropriate appropriate part of the magnetic body. In any case, metabolic energy is needed for many other purposes - in particular, in the transition to activated state, and one could argue that Ling's experiments indicate the existence of an unidentified energy source used when ordinary metabolic energy is not available.

The recent view about TGD suggests that magnetic bodies serve as metabolic energy reservoirs analogous to population inverted lasers defined by excited cyclotron BE condensates of electron and proton Cooper pairs and of various ions. Electronic Cooper pairs are preferred because of their small mass. Quantum credit card mechanism would allow the extraction of energy from the BE condensates by sending negative energy dark photon signals leading to de-excitation of the BE condensates. In this framework the questionable notion of high energy phosphate bond could be replaced with the storage of energy of this kind associated with ATP or with a system containing ATP. The loading of metabolic batteries could take place by sending positive energy dark photons to excite the BE condensates in question and solar radiation could do this as it generates ATP from ADP by adding single phosphate ion. In cell respiration dark photons at the magnetic body of molecules providing the energy would do the same thing using essentially the same mechanism involving electrons and transfer of three protons per ATP through mitochondrial cell membrane.

TGD counterparts for the basic notions of Ling

Ling's vision is very attractive - at least from a TGD point view. One can however wonder whether it can be realized in the framework of standard chemistry. Can the proposed mechanism of association really lead to the selective adsorption? In particular, it is not clear how a given active site of protein can select between ions of same charge? The basic concepts of Ling find natural TGD counterparts and TGD allows one to overcome the restrictions posed by sticking to the framework of standard chemistry.

1. In TGD framework the notion of association would reduce to that of flux tube or a flux tube pair connecting a pair of molecules or molecule (say active site of protein) and ion. Flux tube pair is favored since it allows to interpret reconnection process as touching of closed flux loops associated with A and B so that flux tube pair connecting A and B is generated.

This view fits also nicely with one of the variants of the model of DNA as topological quantum computer [K3]. For the variant in question the two flux tubes would carry electrons at their ends and the spin states of the two electrons would give rise to 4 states in 1-1 correspondence with DNA nucleotides so that one would obtain a realization of DNA code in terms of flux tube pairs.

Flux tube connections allow without further assumptions an additional selectivity in the sense that they can exist between protein active site and on a particular ion only. As such Ling's proposal cannot distinguish between ions of same charge. TGD allows flux tube connections also between various biomolecules and even between larger structures so that the notion of association is not restricted to protein-ion pairs or pairs of active sites. These connections are absolutely essential for the understanding of DNA transcription, translation and various bio-catalytic processes.

2. Adsorption process would mean a reduction of the length of the flux tube by a phase transition induced by the reduction of the value of \hbar_{eff} so that molecules would get near to each other and chemical reaction would become possible.

It is intuitively clear that the length of the magnetic flux tube increases by $\hbar_{eff}/\hbar = n$ in the phase transition $\hbar \rightarrow \hbar_{eff}$, or more generally by $\hbar_{eff,2}/\hbar_{eff,1}$ in the phase transition $\hbar_{eff,1} \rightarrow \hbar_{eff,2}$. Consider a momentum eigenstate $\exp(ipz/\hbar_{eff,1})$ with wave vector $k_1 = p/\hbar_{eff,1}$ defined at a straight flux tube satisfying periodic boundary conditions and therefore satisfying $k = m2\pi/L$, L the length of the flux tube. Suppose that momentum p is conserved in the phase transition. This means that wave vector k is transformed from $k_1 = p/\hbar_{eff,1}$ to $k_2 = p/\hbar_{eff,2}$. To preserve the periodic boundary conditions the length of the flux tube must be scaled by $\hbar_{eff,2}/\hbar_{eff,1}$.

3. Induction process would mean a phase transition inducing reconnection process changing the flux tube connections between molecule pairs. This process would be a quantum phase transition. Whether two molecule can associate depends on the values of the local magnetic fields associated with the reconnecting flux tubes. If the values of both the magnetic field and flux tube thickness are same for the two tubes, association is possible. The value of the flux tube thickness allows to discriminate between different ions of same charge. Flux

tube thicknesses characterize also the state of the system (resting state and various activated states). It is also possible that the protein can vary the thickness of the flux tube and therefore reconnect with different molecules. The change of flux tube thickness would take place in the quantum phase transition changing the connectedness structure of the net formed by molecules. The phase transition can be seen as a motor action of the magnetic body. Magnetic body “wakes up” in the activation process.

Concrete examples about a process in which flux tube connectivities change in a phase transition-like manner would be melting of the “ice layer” around a folded protein bringing the proteins into “open air”. The shortened flux tubes connecting the active sites of the peptide backbone and di-carboxylic amino-acid residues to water molecules would expand in \hbar_{eff} -increasing phase transition and de-reconnect. Water would transform to ordinary water. The resulting closed flux tubes accompanying amino-acids can reconnect with similar loops associated with other active sites of peptide and various secondary structures (such as α -helix) of the protein can form. I have discussed TGD inspired models of protein folding in [K7] in a rather light-hearted manner - mainly as an exercise in order to get familiarity with the notion of magnetic flux tube - and it would be interesting to reconsider the situation by characterizing the active sites by values of magnetic field/cyclotron frequency.

4. Why should the \hbar_{eff} increasing phase transition accompanying the activation process require energy? The following argument suggests an explanation.

- (a) As explained, the length of the flux tube is proportional to \hbar_{eff} and therefore changes. What happens to the thickness of the flux tube? The simplest assumption is that magnetic field strength is preserved so that cyclotron energy scales like \hbar_{eff} if the sheet containing single high frequency boson is transformed to an n -sheeted state with one low frequency boson at each sheet. This brings to mind Bose-Einstein condensate and one can ask whether the formation of BE condensates of genuine bosons could have a microscopic space-time description as n -furcations.

If bosons are Cooper pairs of fermions one encounters a problem with fermion number conservation in positive energy ontology. In ZEO one can in principle avoid this problem but one can argue that the change of fermion number in quantum jump for the positive energy part of the state is too radical an option. One possibility is allowance of fractional fermion number for a given sheet so that one can say that Cooper pair is de-localized between the sheets. One could also start from many-fermion state so that in the final state one would have one Cooper pair per sheet of the n -sheeted covering. For very large values of n this option is highly questionable.

- (b) The conservation of magnetic flux poses an additional constraint. If the number of sheets becomes n -fold and the total flux is conserved, the flux of single sheet must be a fraction $1/n$ the original total flux. Therefore the transition producing n -sheeted covering of flux tube scales down its cross sectional area roughly by a factor $1/n$.
- (c) A further condition comes from the quantization of magnetic flux telling that the net flux is integer multiple of $m_i \hbar_{eff,i}$ in the initial state ($i = 1$) and final state ($i = 2$). Conservation of the magnetic flux gives $m_1 n_1 = m_2 n_2 = m$ so that integer m giving the flux in units of \hbar must be divisible both by n_1 and n_2 . Therefore the phase transition can occur only when the magnetic flux using \hbar as unit is larger than 1 and the allowed values of n_i are factors of m . For large values of integer n_2 this means that the thickness of the magnetic flux in the initial state must be macroscopic.
- (d) What happens to the magnetic energy of the flux tube? By considering a constant magnetic field one easily finds that flux conservation and invariance of B together with longitudinal scaling imply that the energy is scaled by integer $n = \hbar_{eff,2}/\hbar_{eff,1}$. Therefore part of the metabolic energy would be needed to make the flux tubes longer and thus to gain quantum coherence in a longer scale.

One could say that the pumping of the metabolic energy is needed to preserve macroscopic quantum coherence. An attractive idea is that the energy is extracted from some

magnetic body by sending negative energy dark photons. The contraction of flux tubes would occur spontaneously and liberate magnetic energy and reduce the value of \hbar_{eff} . It is natural to interpret this process as dissipation and loss of potentially conscious information.

5. Also the notions of resting state and activated state of biological structure (cell, protein, etc) have natural counterparts in TGD framework, together with the vision about the role of ordered water in biology. I have used the metaphor “cellular winter” for the resting state and “cellular summer” for the activated state induced by the feed of energy to the system so that it begins to self-organize. The TGD inspired model for ordered water (see <http://tinyurl.com/y7z69e8p>) [L17] [K58] relies on topological quantization of the magnetic field giving rise to flux sheets giving rise to layered structure and there is also a connection with the notion of pairs of dark DNA identified as sequences of dark protons at opposite sides of the layer realizing genetic code [L3, K58].

It seems that the basic notions of Ling’s theory - in particular the notion of association, which in my view remains questionable in the framework of standard chemistry - find natural counterparts in TGD framework. The view about cell membrane as Josephson junction leads to a new view about nerve pulse with Josephson currents of Cooper pairs of electrons and fermionic ions and of bosonic ions serving in the key role.

The ground state of the axon would correspond to a propagating soliton sequence mathematically analogous to that appearing in the sequence of mathematical penduli. Nerve pulse would correspond to a propagating perturbation analogous to that obtained by kicking one pendulum to rotate in opposite direction. The detailed modelling of ionic currents is a fascinating challenge, and the view about the pairing of molecules and ions by flux tubes could provide a much more detailed and maybe realistic view about what really happens at cell membrane. It would also allow us to answer the question of whether pumps and channels are needed or whether they could be replaced with the TGD variants of the notions introduced by Ling.

Clearly, the basic question is whether standard biochemistry based on locality assumption is enough to describe living matter or whether the non-local quantum physics involving dark matter at magnetic flux tubes and transforming living matter from a soup of free ions and molecules to a dynamical Indra’s net formed by biomolecules and flux tubes connecting them is needed .

Ling’s view about ionic pumps and channels as compared to TGD views

Ling has empirical evidence that the prevailing ionic pump paradigm is wrong. The basic assumption of the prevailing theory is that both water molecules and various ions inside cell are free. This determines the kinetic equations used in the modelling of ion concentrations in chemi-osmotic theory [I124]. Ling assumes that in the resting state the important ions are adsorbed to proteins and that the activation of the cell changes the situation.

Besides adsorption also the notions of association and induction are needed in the formulation. Ling also emphasizes the role of the cellular water [I97]. Cellular water is not ordinary water but ordered water forming multilayered coverings of biomolecules in the resting state of the cell. This covering prevents various chemical activities of the molecules below the “ice layer”. Only when the ordered water around proteins and other molecules melts, they become active and can participate biochemical reactions via their active anionic or cationic sites to which ions or other biomolecules attach. In this framework the notions of ionic pump and channel must be given up or reformulated.

This picture is consistent with that provided by TGD. Instead of treating cell interior as a soup of free molecules one must treat the system as a kind of dynamical Indra’s web in which flux tube connections are changing all the time. If ions are part of this web, one cannot apply ionic pump theory unless one can neglect the constraints caused by the presence of flux tubes.

The most important implication is that the web dictates to a high degree what biochemical reactions can occur and also takes care that the reactants are brought together when needed by reducing the value of Planck constant for appropriate flux tubes of the web. This transition also induces phase transitions changing the volume

of a given region of cell. Sol-gel phase transition is basic example in this respect. It would seem that the best manner to describe the transfer of various molecules and ions through the cell membrane in TGD framework is as motor activities of the magnetic body of the cell quantum mechanically rather than biochemistry trying to reduce everything to single particle level and to thermodynamics.

The fact is however that channel and pump proteins exist and must have some function. The minimal function would be taking of samples from the chemical environment. Also in the generation of nerve pulses various voltage-gated ion channels play a key role. As will be found, the construction of a simple model for these channels demonstrates that quantal versions of channels and pumps emerge rather naturally in TGD framework: as a matter of fact, channel and pump proteins realize dark Josephson junctions! In particular, dissipation for ionic pumps is minimized since the transfer of ion through the cell membrane is a purely quantal process involving absorption/emission of Josephson photon with large value of \hbar_{eff} . The unexpectedly low dissipation indeed served as a partial motivation of Ling in his approach.

10.4.3 The Role Of ATP According To Ling And In TGD Framework

The notion of high energy phosphate bond and the real role of ATP in biology has been one of the long standing problems of TGD inspired biology. What is certainly clear is that ATP/ADP in which phosphate ion is transferred to the acceptor molecule is a fundamental process. Often this process is interpreted in terms of the transfer of metabolic energy and the view is that "high energy phosphate bond" carries the energy.

TGD inspired theory of consciousness however suggests a deeper meaning for ATP/ADP process.

1. Negentropic entanglement serves in TGD Universe as a correlate for a conscious experience of understanding: negentropic entanglement (NE) (see **Fig.** <http://tgdtheory.fi/appfigures/cat.jpg> or **Fig.** ?? in the appendix of this book) would be transferred in the process. The NE need not as such correspond to conscious experience but its presence makes possible conscious experience. Negentropically entangled systems would define what I have called "Akashic records", whose reading by interaction free quantum measurement (and idealized notion) would give rise to conscious experiences. "Akashic records" would be representations defining the reflective level of consciousness giving rise to memories, predictions, sensory and cognitive representations, etc [K27].
2. My own view have been that ATP either carries and provides, generates, or induces a transfer of NE . I have considered all these options. The key observation is that negentropic entanglement is not a single particle property but characterizes the relationship between two particles. If ATP gives P to a particle B one would expect that B is one of the negentropically entangled particles in the final state. The other particle - call it A - must be negentropically entangled with P .
3. The recent view about NE forced by Negentropy Maximization Principle [K73] is very simple and leads to a connection with dark matter hierarchy, p-adic physics, and quantum criticality [K73] [L18]. The NE which can result in quantum measurement is always maximal entanglement so that density matrix is proportional to unit matrix and correspond to a value of effective Planck constant equal to the integer $\hbar_{eff} = n\hbar$ telling the number of the entangled states. NE is a prerequisite for an experience defining abstraction about the rule having as instances the state pairs appearing in the entangled state. Note that the state pairs are not unique since any unitary transformation acting in the same manner to the two entangled state basis is allowed.
4. In the recent case this would mean that P and A at the ends of the exchanged flux tube $A - - - P$ must have NE characterized by integer n and that the flux tube $A - - - P$ associated with ADP in the initial state is associated with molecule B in the final state. The transfer of NE is indeed in question. The exchange of the flux tube $A - - - P$ can take place using reconnection process as the basic process.

5. NE is conjectured to have as a correlate the braiding of the flux tubes connecting the entangled systems. Does this conjecture survive in the recent case? The flux tubes connect two partonic 2-surfaces at the boundary of causal diamond (CD). The space-time correlate for $\hbar_{eff} = n\hbar$ is the analog of n -sheeted Riemann surface. At the partonic 2-surfaces the sheets coincide. Is it possible for the 3-D projections of the n sheets of single flux tube to become braided (linked and knotted)?

If closed flux loops associated with A and B reconnect to form a *pair of* flux tubes connecting them (as suggested above) one has two alternative reconnections and one of them is uniquely selected by the conservation of flux. The first has minimal braiding and second one does not. Therefore two-tube connections do not guarantee that NE always corresponds to non-trivial braiding.

The following argument assigns the braiding to *single* flux tube.

- (a) TGD also predicts another kind of braiding assignable to the ends of string world sheets at which the solutions of the Kähler-Dirac equation are localized by the conditions that electric charge as spin-like quantum number is well defined for them (eigenstate property). The string ends at the 3-D light-like orbit of the partonic 2-surface define a braid and the other ends of strings at other partonic 2-surfaces get braided during time evolution so that space-like braidings are generated.
- (b) The strings seems to be in a natural 1-1 correspondence with magnetic flux tubes defining their cores. If this is the case the braiding for strings corresponds to the braiding for flux tubes idealized with infinitely thin strings. For $\hbar_{eff} = n\hbar$ one should have a light-like braiding of the ends of strings assignable to different sheets of the n -fold covering at the orbit of partonic 2-surface and this braiding would induce the space-like braiding.

It must be admitted that the connection between braiding and negentropic entanglement remains an attractive conjecture at this moment.

What does the transfer of NE mean metabolically?

1. As already noticed, Ling does not believe that energy is transferred in this process and “high energy phosphate bond” is certainly a questionable notion. I tend to believe that also energy is transferred as well but the open question is where it comes from. One can argue that the energy is needed to overcome the potential wall separating the states distinguished by different braidings.

Remarks:

- (a) Four-dimensional spin glass property of TGD Universe gives rise to a fractal energy landscape and different valleys could be characterized by different braiding structures and phase transitions changing these structures would lead from a valley to another one.
 - (b) Spin glass property means breaking of ergodicity. In a phase transition from resting state to activated state a large number of these transitions would occur and $\text{ATP} \rightarrow \text{ADP}$ transferring the entanglement would also involve the extracting of energy from some magnetic body to overcome the potential wall.
2. There is a large number of candidates for the carrier of the energy and Ling’s findings about metabolic deprivation suggest that several magnetic bodies can in principle provide the metabolic energy. The energy could be assigned to a population inverted cyclotron BE condensate at the magnetic body of P , ATP, the flux tube AP , or a larger system containing ATP.

Ling introduces permanently unfolded proteins as a special system and the magnetic body of single unfolded protein or even the system defined by them could be the carrier of the cyclotron BE condensate. One could imagine that under normal circumstances the magnetic

body assignable to ATP or a system containing it provides the metabolic energy but under metabolic deprivation (as cells in Ling's experiment [I131]) the metabolic energy could be extracted from some other magnetic body. One can compare ATPs with jam jars in the refrigerator: when the jam jar becomes empty, the jam jars in the cellar can come to the rescue. This would require the generation of magnetic flux tube contact to the bigger energy storage using reconnection mechanism and tuning of flux tube strength and would require some time.

3. I have proposed that in photosynthesis solar photons excite the cyclotron BE condensate of electron Cooper pairs at the magnetic flux tubes of some system. This conforms with the idea that magnetic bodies serve as energy supplies and that the motion of the system defined by magnetic body and biological body is basically transformation of cyclotron energy to kinetic energy, chemical energy, heat and other forms of energy needed by the visible part of the organism. TGD assigns to electron with standard value of Planck constant a causal diamond (CD) with a size, which corresponds to 10 Hz frequency defining a fundamental biorhythm. This would conform with the fundamental role of electrons in metabolic energy storage. There are of course many details to be filled in but this picture looks to me very attractive.

10.4.4 Ling's Theory From The Perspective Of TGD Inspired Theory Of Consciousness

Ling formulates his theory using *only the notions of biochemistry and thermodynamics* . This means taking a risk since it is not at all obvious that these notions are enough for understanding life. My personal conviction is that one cannot really understand life without a theory of consciousness. Ling ends up with the notions natural in TGD inspired theory of consciousness but a proper justification of these notions remains lacking because it is simply impossible in the conceptual framework used. Basic problem is of course the non-locality of association process having no description in standard biochemistry.

One can indeed interpret the ATP/ADP process also from the point of view of TGD inspired theory of consciousness from *purely quantal perspective* , and I have already discussed the interpretation of the process as a *transfer of negentropic entanglement*.

1. Flux tubes serve as correlates for attention and ATP serves as re-orientation of the attention by inducing reconnection process. In the transition $A---C \& B---D \rightarrow A---D \& B---C$ by reconnections the attention of A is directed from B to C and attention of B from D to A .
Note: Is direct attention really asymmetric with respect to A and B ? Could attention be symmetric at the fundamental level? Is the "directed" only due to the fact that A is responsible for the variation of flux tube thickness in order to get in tune. The belief that I am aware of the presence of some system but not vice versa might indeed be an illusion: the other system could also be aware about my presence, even in the case that I regard it as "inanimate". It might be however possible to tell which of the two systems performs magnetic motor action generating flux tube connection (by tuning the field value so that reconnection takes place). This argument applies even to the ordinary sensory perception. The conservation of the signed magnetic flux assigns an arrow to the flux tube and gives precise selection rules: the magnitudes of the fluxes are same for reconnected flux tubes of and also signs so that only one reconnection instead of two is possible.
2. Ling's model assigning different roles to permanently unfolded proteins and folded proteins in resting state has a nice interpretation in TGD context. ATPs are attached to the permanently folded proteins in the resting state. The unfolded protein A would be connected to the phosphate P of ATP by flux tube, and one could say that protein A directs its attention to ATP. The permanently folded proteins would be like guards of a bastion in a permanent wake-up state. In resting state the folded proteins would "sleep".
3. As the system is activated, the flux tube connection $A-PB$ is generated and one can say that A directs its attention to B , which could be ion, other protein, or some invader molecule. If A has the role of guard, one can expect that A can control the thickness of the flux tubes of its

magnetic body and in this manner tune to detect the presence of other molecules. Therefore the system of unfolded proteins could define the part of cell which is in permanent wake-up state and monitors the state of the cell. Activation would wake up and unfold the folded proteins and the cell would be in a kind of alarm state as long as external perturbation lasts.

10.5 Capacitor-Like Josephson Junctions As Systems With Large h_{eff}/h ?

Both Tesla coil and magnifying transmitter can be regarded as a pair of systems in which primary drives secondary system with resonant frequency so that energy is transferred to the secondary. Primary has air gap which acts as a switch. Above a critical voltage about 10 V in the air gap a di-electric breakdown occurs and current runs through the gap. What is remarkable is that the duration of the breakdown period is few milliseconds: this is the time scale for the nerve pulse and suggests an analogy with cell membrane which is also a system with ultrahigh voltage between the plates of a capacitor-like system defined by the two lipid layers of the cell membrane. Also the secondary coil, which can be regarded as a plate of capacitor with Earth defining the second plate, develops local di-electric breakdowns seen as “mini lightnings”. The analogy with cell membrane suggests that also these breakdowns are mathematically analogous to the generation of nerve pulse. The glossary of the introduction explains the basic notions related to Josephson junctions.

10.5.1 Cell Membrane As Josephson Junction

I have developed a model for cell membrane as Josephson junction leading also to a model of nerve pulse, and there is interesting to see whether the findings of Tesla could be understood in terms of this model.

1. Cell membrane is assumed to be a Josephson junction in which a Josephson current

$$J = J_0 \sin\left(\frac{Ze \int V(t) dt}{h_{eff}}\right) \quad (10.5.1)$$

is running. For a constant resting potential $V(t) = V_{rest}$ one obtains

$$J = J_0 \sin(\omega t) \quad , \quad \omega = 2\pi f_J \quad . \quad (10.5.2)$$

a current oscillating with the Josephson frequency

$$f_J = \frac{ZeV_{rest}}{h_{eff}} \quad . \quad (10.5.3)$$

Z is the charge of the super-conducting charge carriers. Electronic Cooper pairs with $Z = 2$ are certainly involved and very probably also bosonic ions and Cooper pairs of fermionic ions. The Josephson currents run along super-conducting space-time sheets. $V(t)$ varies rather slowly. Josephson current generates dark Josephson photons with frequencies coming as multiples of f_J having interpretation in terms of EEG and its generalizations [K44].

The dominating contribution to the membrane voltage is constant resting potential. Besides this there is varying part reflecting various activities near cell membrane and the idea is that dark Josephson photons emitted by Josephson current communicate sensory information about these activities to the magnetic body.

2. Without further assumptions one cannot predict the value of $h_{eff} = nh$. One can however end up with a prediction for h_{eff} by considering a more general situation in which the voltage containing time dependent part - briefly "AC part".

- (a) Suppose that this contribution is periodic with a period characterized by AC frequency f_{AC} . This does not mean that the AC part is of simple sinusoidal form but only that $V(t)$ is a superposition of harmonics of some fundamental frequency f_{AC} containing also a constant part defining the resting potential. The alternating part of voltage is expected to relate closely to cyclotron contribution to the membrane voltage so that cyclotron frequency f_c of electron, proton or some ion defines a good candidate for f_{AC} which would depend on cell. Neglecting nuclear binding energies the cyclotron frequencies of ions in given magnetic field are subharmonics of proton's cyclotron frequency.
- (b) The natural assumption is that in dynamical equilibrium the periodicity of Josephson current is that of the alternating current. This gives as the first guess the condition

$$f_J = f_{AC} \quad (10.5.4)$$

One can also consider also sub-harmonics:

$$f_J = \frac{f_{AC}}{l} \quad , \quad l = 1, 2, \dots \quad (10.5.5)$$

so that Josephson radiation would be seen as master and cyclotron radiation as slave. This condition fixes the value of h_{eff} :

$$\frac{h_{eff}}{h} = l \times \frac{ZeV_{rest}}{hf_{AC}} = n = 1, 2, \dots \quad , \quad l = 1, 2, \dots \quad (10.5.6)$$

From this formula one can readily calculate the value of h_{eff} assignable to say EEG frequencies and integer valuedness of h_{eff}/h fixes the spectrum of EEG frequencies and implies that this spectrum can be regarded as union of sub-harmonics of maximum frequencies f_{max} such that each sub-harmonic corresponds to its own value of h_{eff} . The cyclotron frequencies of various ions in given magnetic field correspond in first approximation to various values of n in above equation and by small tuning of the magnetic field strength associated with flux tubes carrying particular kind of ions the same formula applies to all ions.

- (c) For $f_{AC} = f_J$ option the value of h_{eff} would be completely fixed by the periodic perturbation and the system produces dark photons with harmonics of Josephson frequency. For more general option h_{eff} is divisible by integer l which would naturally relate to p-adicity with p-adic prime appearing as a factor of l . The results is rather powerful and gives the long sought for quantitative grasp about the hierarchy of effective Planck constants.
3. The integer quantization of h_{eff}/h implies that the resting potential of the cell membrane obeys integer quantization for given value of l and that the changes of the membrane potential correspond to quantized change of the charge of the effective capacitor from $Q = CV$. The resting potential of the cell membrane is indeed known to be quantized. The unit for the resting potential is known as miniature end plate potential (<http://tinyurl.com/y8czhhpm>) of order $\Delta V = .5$ mV to be compared with the resting potential of order 60 mV. This would give $\Delta h_{eff}/h_{eff} \sim 1/100 = \Delta n/n$ if neither l nor f_{AC} changes. The changes of h_{eff} would be of order one per cent.

I have made a conjecture that the phase transitions changing h_{eff} are such that $h_{eff}/h = n$ is replaced with its factor. In this case the change of h_{eff} is large and cannot apply in the case considered. h_{eff}/h can be kept however constant if the change $l_i \rightarrow l_f$ compensates the change of V_{rest} so that one would have

$$\Delta \frac{V_{rest}}{V_{rest}} = \frac{l_i}{l_f} - 1 \simeq -\frac{\Delta l}{l} .$$

l is however expected to be rather small integer on basis of the model of EEG so that Δl need not compensate small changes of V_{rest} . h_{eff}/h remains also invariant if V_{rest} and magnetic field defining cyclotron frequency can scale in the same manner. This follows from the basic conditions automatically. If neither l or B is changed then a phase transition satisfying $\Delta n/n < 1$ must occur and proceed via a transition to an intermediate state with $h_{eff} = h$ - that is ordinary matter.

10.5.2 Quantization Of The DC Voltage Of Capacitor From The Quantization Of Charge

For a given value of $f_{AC} = lf_J$ the formula for h_{eff}/h implies quantization of the capacitor voltage. The quantization of the voltage of a capacitor follows also from the quantization of charge implying $\Delta Q_{min} = e$ as the minimal change of charge. This gives a condition on the AC frequency f_{AC} :

$$\Delta(\frac{h_{eff}}{h}) = l \frac{Ze\Delta V_{min}}{hf_{AC}} = lr \frac{Ze^2}{Chf_{AC}} = k . \quad (10.5.7)$$

Here r is the number of elementary charges in the pulse changing the voltage. If this condition is assumed to hold true for all values of l and r , one can conclude that

$$\frac{Ze^2}{Chf_{AC}} = s = 1, 2, \dots . \quad (10.5.8)$$

and that s divides k . This is true for any k for $s = 1$. This would give a quantization condition for $\lambda_{AC} = c/f_{AC}$:

$$\lambda_{AC} = \lambda_{min} = \frac{\hat{C}}{2Z\alpha} , \quad \alpha = \frac{e^2}{4\pi\hbar\epsilon_0 c} \simeq 1/137 . \quad (10.5.9)$$

$$\hat{C} = \frac{C}{\epsilon_0} , \quad \epsilon_0 = 8.854 \times 10^{-12} F/m$$

Equivalently, one would have

$$f_{AC} = f_{max} = \frac{c}{\lambda_{min}} = \frac{2Z\alpha c}{\hat{C}} . \quad (10.5.10)$$

λ_{AC} as the minimum wave-length is therefore dictated by capacitance. In biological applications $f_c = f_{max}$ follows.

Before discussing concrete examples note that C is expressed using Farad as unit: micro-, nano-, and picofarad are more natural units. \hat{C} having dimension of length makes manifest the geometric meaning of C . The allowed values of f_{AC} must come as sub-harmonics of the maximum frequency determined completely by the capacitance.

1. For a plane capacitor one has

$$\hat{C} = \frac{\epsilon_r A}{d} . \quad (10.5.11)$$

Here $\epsilon_r = \epsilon/\epsilon_0$ is the relative permeability, and A and d are the area of the plate and d the distance between them. For $\hat{C} = 1$ m one has

$$\lambda_{min} \simeq \frac{\hat{C}}{m} \times 67.5 \quad , \quad f_{max} \simeq \frac{1}{\hat{C}/m} \times 4.4 \times 10^6 \text{ Hz} \quad . \quad (10.5.12)$$

2. This gives strong bound on the capacitance. For instance, in the experiments of Tesla f_{AC} is in the range 20 – 100 kHz. For $f_{AC} = f_{max}$ the corresponding range for \hat{C} is 1.15 mm-0.23 mm. For $f_{AC} = f_{max} = 10$ kHz one would have $\hat{C}/m \simeq 2.30$ mm.
3. Kennelly-Heaviside layer has thickness $d = 90 - 150$ km and be approximated as a spherical capacitor with

$$\hat{C} = \epsilon_r \times \frac{4\pi R^2}{R - \frac{R^2}{R+d}} \simeq \frac{4\pi R^2}{d} = \frac{A}{d} \quad . \quad (10.5.13)$$

In this case one has $f_{max} \simeq 19$ minutes.

10.5.3 Constraint On Cyclotron Frequency

The TGD inspired model of EEG [K44] suggests that f_J assignable to the neuronal membrane is around 5 Hz. This would suggest that it is second sub-harmonic of an ionic cyclotron frequency around 10 Hz (say that of Mg^{++}) or the third sub-harmonic of cyclotron frequency of Ca^{++} equal to 15 Hz. This would support the formulas

$$f_J = \frac{f_c}{l} \quad , \quad f_c = f_{max} = \frac{2Z\alpha c}{\hat{C}} \quad . \quad (10.5.14)$$

Through these equations the field values at magnetic flux tubes, cell membrane potential, and the shape and size of cell membrane would be in tune. This constraint relates cyclotron frequency and therefore the value of the magnetic field at given flux tube to the capacitance. In terms of the magnetic length $L_B = \sqrt{h/eB}$ this gives rise to the following equivalent correspondences

$$\begin{aligned} L_B &= \sqrt{\frac{r_C \hat{C}}{\alpha}} l \quad , \\ \hat{C} &= \frac{\alpha L_B^2}{l r_C} \quad . \end{aligned} \quad (10.5.15)$$

Some numerical correspondences are helpful in quantitative estimates. $B = 1$ Tesla corresponds to magnetic length $L_B \simeq 64.3$ nm, and capacitance of 1 Farad to the “capacitance length” $\hat{C} = 1.1 \times 10^{11}$ m. Compton length for electron is $r_C \simeq 2.43 \times 10^{-12}$ m.

Some comments from the point of view of the model of cell membrane as super conductor are in order.

1. The effects of ELF radiation on vertebrate brain suggest the presence of endogenous magnetic field with field strength $B \simeq 2B_E/5$, where $B_E = .5 \times 10^{-4}$ T is the nominal value of the Earth’s magnetic field with magnetic length $L_B = 14.4 \mu\text{m}$. For electron the corresponding value of \hat{C} would be $\hat{C} = .62$ m for $l = 1$. For large neurons with radius of order 10^{-4} m one has $\hat{C} \simeq 12.6$ m² for $l = 1$. For $l > 1$ the proportionality $\hat{C} \propto 1/l$ however allows smaller cell sizes.
2. For proton and ions \hat{C} would be obtained by scaling down the electronic \hat{C} by the mass ratio $m_E/Am_p \sim 2^{-11}/A$, A the mass number of nucleus. For proton one would have $\hat{C} = 3.3 \times 10^{-4}$ m and for Ca^{++} ion with mass number $A = 40$ one would have $\hat{C} \simeq 1.3 \mu\text{m}$, which corresponds to the length scale of cell nucleus and could characterize nuclear membrane as capacitor.

3. Somewhat unexpectedly, ions would correspond to a capacitor assignable to nuclear membrane whereas electron would correspond to size scale of large neuron. Alternatively large value of l could allow smaller cell sizes. Electron could also correspond to a multicellular system behaving effectively as a single capacitor by quantum coherence. DNA double strand and its subsystems might also correspond to the capacitor-like systems involved with both electrons, protons, and ions.

10.5.4 What About More General Capacitor-Like Systems?

There is a temptation to assume that the situation for the air gap of Tesla coil and for the capacitor formed by the secondary and Earth is same as for the cell membrane except that the DC voltage is replaced with AC voltage. The generalization might apply quite generally to any capacitor-like system.

1. Now electronic and possibly also protonic Cooper pairs with large \hbar_{eff} would be the current carriers. Josephson currents would be present all the time. Dielectric breakdown would be analogous to nerve pulse. The analog of the membrane potential would be defined by the voltage associated the Earth's electric field $E_E \simeq 100 \text{ V/m}$ unless DC voltage is present. Note that the orientation of the capacitor with respect to the Earth's electric field matters. This would define Josephson frequency in absence of other currents and one would have Josephson current even for an ordinary capacitor with frequency $f_J = ZeV/\hbar_{eff}$. Same conditions would apply to f_J and f_{AC} as for cell membrane system. Only V_{rest} would be replaced with V_E so that one would have

$$\frac{\hbar_{eff}}{h} = \frac{ZeV_E}{hf_{AC}l} = n, \quad l = 1, 2, 2, \dots, \quad n = 1, 2, \dots \quad (10.5.16)$$

for the space-time sheet along which the Josephson current runs. The value of effective Planck constant is therefore completely fixed! Rather remarkably, the proposed amplitude modulation mechanism predicts exactly the same value $\frac{\hbar_{eff}}{h}$ as ratio of Josephson frequency for ordinary Planck constant and of AC frequency and it might be possible to regard the two mechanisms as equivalent.

2. If *all* capacitor-like systems carry a small oscillatory Josephson current satisfying $f_J = f_{AC}$ ($l = 1$ in more general formula) in presence of AC current, one could assign to a capacitor a unique value of \hbar_{eff} depending on it orientation with respect to Earth's electric field. This would predict production of dark photons with the AC frequency and its harmonics. Also a capacitor added to DC circuit would carry a small dark Josephson current but now one cannot predict the value of \hbar_{eff} as found in the beginning. This indeterminacy would conform nicely with the quantum criticality of TGD Universe: a small periodic perturbation would fix the value of \hbar_{eff} . The new physics might be present in ordinary AC circuits and might relate to the poorly understood $1/f$ noise in electric circuits. Dark Josephson currents and probably also supra currents would be present in ordinary circuits and one might imagine building a technology based on this new form of high T_c superconductivity.
3. By introducing to the Josephson potential constant part artificially, one can increase the value of \hbar_{eff}/h and cell membranes have indeed done just so.

10.5.5 What $F_J = F_{Ac}/L$ Condition Implies For Earth's Electric Field?

As argued, if the situation is analogous to asymptotic self-organization pattern, the Josephson current must be periodic having the same periodicity as the external AC voltage. This is guaranteed if $V_J(t)$ is a superposition of Fourier components coming in multiples of f_{max} .

1. If this condition is satisfied and if the voltage $V(t)$ contains a DC part - containing at least the contribution V_E associated with the Earth's electric field - to the Josephson voltage, then the condition $f_J = f_{AC}$ reads as

$$f_J = \frac{ZeV_E}{h_{eff}} = \frac{f_{AC}}{l} = \frac{f_{max}}{l} \quad , \quad f_{max} = \frac{2Z\alpha}{\hat{C}} \quad . \quad (10.5.17)$$

The value of h_{eff}/h for $f_{AC} = f_{max}$ would be given by

$$\frac{h_{eff}}{h} = \times \frac{eV_E}{hc} \frac{\hat{C}}{2\alpha l} = n \quad . \quad (10.5.18)$$

2. This in turn poses a condition to \hat{C} . For a plane capacitor one has $\hat{C} = \epsilon_r A/d$. This formula applies in good approximation also to spherical capacitor. For a more general capacitor-like system - defined by say folded cell membrane or the neuronal membrane containing also axon and dendrites - the capacitance can be parametrized as $\hat{C} = yA/d$.

For $E_E = x \times 100V/m$ one $eV_E/hc = d \times x \times 10^2 eV/hc \times m^{-1} = d \times 1.24 \times 10^8 x \times m^{-2}$ and one obtains

$$\frac{h_{eff}}{h} = 1.24 \times 10^8 \epsilon_r xy \times \frac{A}{m^2} \frac{1}{2\alpha l} = n \quad . \quad (10.5.19)$$

This translates to a quantization condition for the area of the plane capacitor:

$$A = nl \times A_{min} \quad , \quad A_{min} \simeq \frac{118}{\epsilon_r xy} (\mu m)^2 \quad . \quad (10.5.20)$$

The size scale of the minimal capacitor is that of cell: in cell scale nk is small integer and therefore also n is near unity. That condition correctly relates the size scale of the cell to the magnitude of the electric field of Earth strongly suggests that both E_E and B_E have been key players in the evolution of life and also supports the vision about Kennelly-Heaviside layer as the analog of cell membrane.

3. As discussed, also Kennelly-Heaviside layer with thickness $d \sim 100$ km can be approximated as a spherical capacitor with $\hat{C} \simeq xA/d$. One obtains expression for nl from the expression of A as a multiple of A_{min} as

$$nl = \epsilon_r xy \times 4.56 \times 10^{24} \quad . \quad (10.5.21)$$

The allowed values of n and l are huge. In the case of cell membrane the values of l would be however rather small. For the value of n corresponding to $n \sim l$ one has $n \leq 2 \times 10^{12}$. The frequency of dark variants of visible photons with energy 2 eV would correspond to dark photon with frequency around 150 Hz, which is somewhat above EEG range.

10.5.6 Cell Membrane, DNA Double Strand, And Cortical Layers As Capacitor-Like Josephson Junctions

Earth's electric field E_E would not allow large h_{eff} Josephson photons generated by capacitor-like Josephson junctions with much larger size than that of cell. By previous arguments neurons can emit large \hbar Josephson photons and the high value of the resting potential saves the situation: large h_{eff}/h as a prerequisite of intelligent life provides the answer to the question why strong voltages are needed in biology. The resting potential $V_{rest} = .06$ V is by a factor $x = V_{rest}/E_E d \simeq 6 \times 10^4$, $d = 10^{-8}$, stronger than that corresponding to E_E .

Cell membrane as capacitor

Using spherical capacitor as a model for the cell membrane as starting point in the parameterization of capacitances as $\hat{C} = yA/d$, the quantization condition deriving from quantization of elementary charges reads as

$$\begin{aligned} \frac{h_{eff}}{h} &= 7.44 \times 10^{14} \epsilon_r y \times \frac{A}{m^2} \times \frac{1}{2\alpha l} = n , \\ A &= nl \times A_{min} , \quad A_{min} \simeq \frac{20}{\epsilon_r y} \times (nm)^2 . \end{aligned} \quad (10.5.22)$$

A scale of about 5 nm defines the size scale of the minimal capacitor. $n \sim 2^{16}$ is possible even for the size scale of cell nucleus.

For a large neuron with size scale of 10^{-4} m one obtains $h_{eff}/h \sim 10^{10}$. The area of cell membrane can be increased by folding and cell interior is indeed filled with a folded membrane. This allows even larger value of h_{eff}/h at neuronal level. Therefore one can understand the required large values of h_{eff}/h and a direct correlation between the evolutionary level measured by h_{eff}/h and cell size scale and total membrane area is predicted.

DNA double strand as capacitor?

Each DNA nucleotide carries two units of negative charge. Could one somehow assign a pair of cylindrical surfaces with the highly coiled DNA double strand and describe it as a cylindrical capacitor? Where are the positive charges? Are positive charges associated with Earth identified as a cylindrical surface around DNA with radius of order $L(151) = 10$ nm defining the radius of the chromosome? And is the idealization as a perfect conductor meaning constant charge distribution at the coiled inner cylindrical surface and outer chromosome surface really justified?

In any case, the capacitance of co-axial cable is given by

$$\hat{C} = \frac{2\pi\epsilon_r \times L}{\log(R_2/R_1)} \quad (10.5.23)$$

is good approximation for the capacitance of the system if it behaves as a conductor. \hat{C} depends linearly on length L . Similar formula is expected to apply in the first approximation also to the coiled DNA strand defining chromosome. The value of h_{eff}/h would increase as the total length of DNA strand increases during evolution: for human DNA the length is about $L \sim 1$ m. The linear charge density per unit length is for double strand $4e$ per nucleotide pair and makes $6e/nm$ so that the total charge is $6eL/nm$ and about 6×10^9 for human DNA. $R_1 = 1$ nm and $R_2 = 10$ nm are reasonable first estimates.

The expressions for various parameters are

$$\begin{aligned} \hat{C} &= \frac{2\pi\epsilon_r \times L}{\log(R_2/R_1)} \simeq 14.5\epsilon_r L , \\ f_{max} &= 2Z\alpha \times \log\left(\frac{R_2}{R_1}\right) \times \frac{c}{2\pi\epsilon_r \times L} \simeq 3.2 \text{ MHz} , \\ \frac{h_{eff}}{h} &= n = \frac{24\pi}{l} \times (L/nm) \simeq \frac{1}{l} \times 75.4 \times (L/nm) , \\ L &= nlL_{min} , \quad L_{min} = \frac{1}{24\pi} \text{ nm} \simeq .13 \text{ Angstrom} . \end{aligned} \quad (10.5.24)$$

For $L = 1$ m (of the order of the total length of human DNA) one obtains $h_{eff}/h \simeq .75 \times 10^{11}/l$. Cyril Smith [J28] claims that for water memory frequency ratio $f_h/f_l = 2 \times 10^{11}$ is special: this ratio corresponds in TGD framework to h_{eff}/h [K58]. $L_{min} \simeq .1$ Angstrom means that non-standard values of Planck constant can be important already for the shortest possible DNA strands. f_{max} is of order MHz and for largest possible values of l ($n = 1$) $f_J = f_{max}/l$ is of order 10^{-5} Hz: $n = l$ gives $f_{max} \simeq 10$ Hz which is perhaps not an accident.

Also proteins are charged (the sign and magnitude of the charge depends on pH of the environment) and this suggests that also they define capacitor type Josephson junctions.

Cortical layers as Josephson capacitors

TGD Universe is fractal and therefore a highly attractive idea is that also the highly folded layers of various brain areas correspond to capacitor-like systems acting as Josephson junctions. Also the six cortical layers- decomposing to cortical columns of radial size scale of order mm would correspond to Josephson junctions but in smaller length scale. The hierarchy of Planck constants would thus make itself directly visible in the structure of brain.

The total area of cerebral cortex (<http://tinyurl.com/yabv12gs>) is about .25 m². For $A = .25 \text{ m}^2$ - possibly making sense for the highly neural circuits associated with the highly folded membrane-like structure defined by cortical layers - one would have $nl = 1.25 \times 10^{14} \times (\epsilon_r/1.18)$ so that $h_{eff}/h = n \leq 1.5 \times 10^{14} \epsilon_r$ holds true. The frequency of a dark variant of 2 eV visible photon would be about 40 Hz for $\epsilon_r = 1$. This happens to be the celebrated thalamo-cortical resonance frequency (<http://tinyurl.com/8vt8pzu> suggested to be an important correlate for consciousness).

This estimate can be criticized since the value of the voltage is taken to be the resting potential. 10-20 mV is the typical value of the oscillating EEG potential (<http://tinyurl.com/2mapqg>) when measured from subdural electrodes and one expects that the constant part has magnitude which is larger: in the case of cell membrane by a factor of order 100. If the ratio is same in the scale of cortex, one would have “resting potential” of order 1.2-2-4 V which is by a factor 50-100 higher than resting potential. The average thickness of human cortex is 2.8 mm - largest for mammals but for mouse (2.2 mm) larger than for macaque (1.7). In the Earth’s electric field $E = 100 \text{ V/m}$ the maximum voltage difference over is 0.28 V of this distance which would be roughly twice the nominal value .06 V of the resting potential. Interestingly, the thickness of cortex is known to be thicker for meditators (<http://tinyurl.com/25rncxg>) [J64]: in principle this means larger value of h_{eff} . One can wonder what happens when the local section of (folded) cortical layer is not orthogonal to the Earth’s electric field. If cortical layer behaves as an ideal conductor, the surface charges should arrange the situation in such a way that the voltage is same along cortical layers and that the orientation of head does not matter.

The quantization of capacitance basically due the quantization of elementary charges and $f_J = f_{AC}/l$ condition is rather strong. Cell membrane is however able to change its shape and could find a shape in which the condition is satisfied.

Artificial life?

The above considerations inspire the question about a recipe for building primitive life forms. Both magnetic and electric fields are needed. Concerning the electric part of the system the following recipe comes in mind.

1. Take a capacitor-like system with as large area as possible and feed in electric field as sum of as strong as possible DC part and AC part. From charge quantization the frequency characterizing the periodicity of AC part must be subharmonic of a fundamental frequency expressible in terms of the capacitance. Capacitance itself and thus the area of capacitor is quantized too. In living matter the quantization rules require a flexible geometry. This might explain why living matter is “soft”. Cell membranes can indeed vary their capacitance by deforming their shape. The frequency f_{max} identified as cyclotron frequency f_c in turn can be varied by varying the flux tube thickness. Maybe this kind of softness is required for artificial cells too. The resulting system is critical in the sense that it satisfies very strong quantisation conditions but state function for density matrix makes the system critical and thus gives excellent hopes for “self-organized quantum criticality”.
2. The inclusion of magnetic fields is certainly an essential element. In the case of cell membrane and DNA one assumes that flux sheets traverse through DNA double strand and cell membrane and also flux tubes connecting DNA and lipids are assumed. How could the magnetic body be realized artificially? In Tesla coil secondary serves both as inductance and capacitor so that also magnetic body is present and is able to perform “motor actions” essential for generating reconnections. Here the identification $f_J = f_{AC}/l = f_{max}/l = f_c/l$ would give an additional constraint: $f_c = f_{max}$.

Remote metabolism and the question about simplest possible metabolic pathway

Remote metabolism suggests an extremely simple manner to produce ATP without the need for metabolic machinery and allowing to avoid production of free radicals causing molecular damage. This mechanism could explain the reported ability to survive without nutrition described in the introduction [169, 142].

1. Drop out all initial steps of the oxidative phosphorylation appearing in both photosynthesis and cell respiration (<http://tinyurl.com/2cfx4x>), and replace the last step involving formation of ATP using ATP synthase (pumping protons against membrane resting potential) with much simpler process.
2. The final step in oxidative phosphorylation involves dropping of 4 protons through the cell membrane. The liberated electrostatic energy goes to ATP as it is formed. The electrostatic energy ZeV_{rest} , $E = eV_{rest} \simeq .06$ eV depends on the charge Z of the charged particle only. One can therefore imagine several basic units: two Cooper pairs of protons, two Cooper pairs of fermionic ions or two doubly charged ions such as Ca^{++} , and electron Cooper pairs moving in opposite direction through the membrane could liberate same energy to be used to build ATP. One could even say that resting potential defines fundamental metabolic energy quantum.
3. The loading of metabolic batteries could take place by remote metabolism in very simple manner: charged particles with charge $\pm 2e$ send negative energy Josephson photon energy $E = -2eV_{rest}$ to some magnetic body and in this manner gain opposite energy as a recoil energy and is pumped to the other side of the membrane.
4. Note that the fundamental energy quantum would be about .06 eV. Metabolic energy quantum has nominal value of .5 eV. This process would not therefore use dark variants of visible photons (decaying to bio-photons) but dark variants of infrared photons decay to IR counterparts of bio-photons. A killer test for the proposal could be a check whether IR analogs of bio-photons with these energies exist.

Absorption of photons at Josephson frequency is obviously a very primitive manner to receive metabolic energy. What about photosynthesis? Could it rely on the absorption of visible photons at Josephson frequency kicking ions to the other side of the photo-receptor membrane, dropping back spontaneously and transferring their electrostatic energy to the electrons in the electron transport chain? This would eventually lead to the kicking of four protons (or two proton Cooper pairs) through the membrane and generation of ATP? Photosynthesis would transform solar photons as natural metabolic energy quanta assignable with near vacuum extremals to the IR metabolic energy quanta. In [K9] and accompanying JNL article it is demonstrated that this kind of scenario can be considered.

1. TGD suggests two possible states for cell membrane corresponding to far from vacuum extremals and near to vacuum extremals for Kähler action [K24]. For the latter one the Z^0 contribution to membrane potential would dominate and the energies of charged particles defined by membrane voltage are proportional to $Q_Z g_Z V_Z$. Basically due to the large isospin of nuclei the scaling of Josephson energies is large but the energies remain below visible range. If Weinberg angle is reduced from $p = \sin^2(\theta_W) = .02397$ to $p = .0295$, the electrostatic energy differences over membrane for ions are scaled up to energies of visible photons for $V = .055$ eV [K24].
2. The following argument demonstrates that the questionable assumption about Weinberg angle for near to vacuum extremals is actually un-necessary.
3. From **Table 10.1** one indeed learns that for $p = .0295$ and $eV_{rest} = .055$ eV the Josephson energies for Na^+ , Cl^- , K^+ and Ca^{++} for near to vacuum extremal using eV as a unit are 2.2, 2.74, 3.07 and 2.31. The peak energies for red, green, blue and white light are 2.19, 2.32, 3.06, and 2.49 eV respectively. For ordinary value of Weinberg angle given by $p = \sin^2(\theta_W) = .23$, the energies are below visible energies, and this motivated the hypothesis that Weinberg angle is different for near to vacuum extremals. This hypothesis can be criticized.

Ion	Na^+	Cl^-	K^+	Ca^{+2}
$E_J(.04 \text{ mV}, p = .23)/eV$	1.01	1.40	1.51	1.76
$E_J(.065 \text{ V}, p = .23)/eV$	1.64	2.29	2.69	2.73
$E_J(40 \text{ mV}, p = .0295)/eV$	1.60	2.00	2.23	1.68
$E_J(50 \text{ mV}, p = .0295)/eV$	2.00	2.49	2.79	2.10
$E_J(55 \text{ mV}, p = .0295)/eV$	2.20	2.74	3.07	2.31
$E_J(65 \text{ mV}, p = .0295)/eV$	2.60	3.25	3.64	2.73
$E_J(70 \text{ mV}, p = .0295)/eV$	2.80	3.50	3.92	2.94
$E_J(75 \text{ mV}, p = .0295)/eV$	3.00	3.75	4.20	3.15
$E_J(80 \text{ mV}, p = .0295)/eV$	3.20	4.00	4.48	3.36
$E_J(90 \text{ mV}, p = .0295)/eV$	3.60	4.50	5.04	3.78
$E_J(95 \text{ mV}, p = .0295)/eV$	3.80	4.75	5.32	3.99
Color	R	G	B	W
E_{max}	2.19	2.32	3.06	2.49
energy-interval/eV	1.77-2.48	1.97-2.76	2.48-3.10	

Table 10.1: Table gives the prediction of the model of photoreceptor for the Josephson energies for typical values of the membrane potential. For comparison purposes the energies E_{max} corresponding to peak sensitivities of rods and cones, and absorption ranges for rods are also given. R, G, B, W refers to red, green, blue, white. The values of Weinberg angle parameter $p = \sin^2(\theta_W)$ are assumed to be .23 and .0295. The latter value is forced by the fit of Josephson energies to the known peak energies.

4. In the earlier version of the model I however failed to notice that it is Cooper pairs of fermionic ions rather than ions that must be the charge carriers. For Cooper pairs of Na^+ , Cl^- , and K^+ , $p = .23$ and $E_J = .04$ eV assignable to visual receptors the Josephson energies are doubled being 2.02, 2.80, 3.02 eV and these energies could correspond to peak energies for visible photons. Therefore there is no need to make the questionable assumption $p = .02397$ nor to assume that instead of fermionic ions one has their exotic bosonic counterparts allowed by the nuclear string model [L3]. For electron the Josephson energy would be scaled by a factor $-1 + 1/2p$ to $E(e) = 1.0859 \times eV_{rest}$ for $p = .2397$. For neutrino the energy would be given by $E(\nu) = -0.0859 \times V_{rest}$: for $p = 1/4$ it would vanish by the vanishing of vectorial part of Z^0 charge. For proton the energy would be $E(p) = (3 - 1/2p)V_{rest} = .914 \times V_{rest}$ and for neutron $E(n) = V_{rest}/2p = 2.086 \times V_{rest}$.

Could photo-reception (<http://tinyurl.com/6z7883v>) in rods and cones and photosynthesis be initiated by the same first step - a resonant absorption of visible photon by a ionic Cooper pair at its Josephson frequency and kicking it through photosystem II (<http://tinyurl.com/ydfxrmcu>) part of thylakoid membrane, which would therefore be near-to-vacuum extremal? If thylakoid membranes are near to vacuum extremals, the Josephson energy of proton Cooper pairs would: $E_J = 2eV_{eff}$, $eV_{eff} = (3 - x) \times eV_{thr}$, $x = 1/2p$. For $eV_{thr} = .044$ eV favored by the considerations of [K9] this would give $eV_{eff} = .040$ eV. This happens to be just the nominal threshold potential for sensory receptors. After the absorption the energy of photon would be transferred to electron transfer chain in far from vacuum extremal region of the thylakoid membrane.

Remote metabolism for visible photons would mean the transfer of ion through thylakoid membrane inside photosystem II induced by sending of negative energy photon. One can wonder whether plants could make photosynthesis more effective by by emitting long wave length dark photons received by a source of visible light. Similar mechanism would make possible active vision.

10.5.7 Further Comments

The model deserves some further comments.

1. It should be made clear that the basic assumption $f_J = f_{AC}/l = f_c/l$ is perhaps unnecessarily strong. The idea that Josephson voltages and “alternating voltages” assignable

to cyclotron BE-condensates are in resonant interaction requires only $f_J = (k/l)f_c$, where k/l is small rational. It is however easy to generalize the above estimate by replacing l with k/l .

2. The above arguments lead to a possibly new mechanism producing dark photons and allowing a control of the value of \hbar_{eff}/\hbar in terms of periodic perturbation of DC voltage. Also very tight conditions on system parameters, such as for allowed values of f_{AC} follow and the charge of the charge pulse follow. I have proposed also amplitude modulation as a mechanism of production of dark photons. In this case one modulates high frequency (f_h) em field with low frequency (f_l) em field and the value of \hbar_{eff}/\hbar is simply the ratio of frequencies: $\hbar_{eff}/\hbar = f_h/f_l$. The mechanism requires that the frequency ratio is integers. The two mechanisms make the same prediction but it is not clear whether one should regard them as equivalent.
3. Especially fascinating is the consistency of the resulting picture with the vision about cell membrane and even larger structures of brain as plane capacitor -like Josephson junctions maximizing their area to maximize the values of \hbar_{eff}/\hbar . This would give direct quantitative grasp to evolution as increase of \hbar_{eff}/\hbar .
4. The model provides a quantitative formulation of an old vision. Already more than fifteen years ago I talked about a fractal hierarchy of super-conductors and Josephson junctions [K87] of which the cell membrane is only one representative. I proposed that even the region between ionosphere and Earth's surface could be analogous to cell membrane and that lightnings are analogous to nerve pulses. It was however not possible to concretize the idea at that time. Now the situation has changed.

Kennelly-Heaviside layer of thickness about 150 km could have interpretation as the analog of cell membrane. The analogy with cell membrane as Josephson junction goes actually further. Kennelly-Heaviside layer decomposes to two layers with thickness of order 80 km: the lower one corresponds to atmosphere. 172 km corresponds to the thickness assignable to the electron Compton scale $L_e(239)$, which corresponds to the next Gaussian Mersenne prime after $L_e(167) = 2.5 \mu\text{m}$ defining the size scale of cell nucleus. Therefore $L_e(237) = 86$ km would correspond to the thickness $L_e(149)$ of lipid layer and 176 km to the thickness $L_e(151)$ of the lipid layer associated also with Gaussian Mersenne. Kennelly-Heaviside layer would be the analog of cell membrane and Earth interior the analog of the cell interior in accordance with early speculations [K67, K65].

One can consider an alternative interpretation based on p-adic length scales $L(k)$ rather than scaled up Compton lengths $L_e(k) = \sqrt{5}L(k)$. The p-adic length scale $L(239)$ -as opposed to scaled up electronic Compton scale $L_e(239) = \sqrt{5}L(239)$ is 78.7 km - 20 per cent smaller than 100 km. Remarkably, also M_{241} is Gaussian Mersenne and corresponds to the scale $L(241)$ which equals to 157.4 km. The two kinds of tectonic plates (continental and oceanic) would be analogous to the lipid layers of cell membrane. Note that 78.7 km is rather precisely the thickness of the atmosphere above which there is ionosphere (see <http://tinyurl.com/lqr85j>) [F2]. The thickness of Kennelly- Heaviside layer (see <http://tinyurl.com/25ur2t1>) [F3] inside which radio waves used in terrestrial radio communications propagate, has thickness about 150 km which roughly corresponds to $L(241)$. Also the fact that continental lithosphere (see <http://tinyurl.com/d96kw>) [F5] has typical thickness of 200 km ($L(239)$) whereas oceanic lithosphere is 100 km thick ($L(237)$) fits qualitatively with the proposed formation mechanism of continental tectonic plates.

The first guess for the Josephson frequency would be as Schumann frequency $f_S \simeq 8$ Hz or at least a frequency which is of the same order of magnitude. From the knowledge of the magnitude of the electric field of Earth and from the value of Schumann frequency one can deduce the value of \hbar_{eff}/\hbar associated with this system. The radial electric field of Earth is not constant and goes to practically zero within few kilometers. At the surface of the Earth it is about $E = 100$ V/m so that for 10 km height one has $eV_E < 1$ MeV to be compared with the membrane potential $eV_{rest} \simeq .06$ eV. The value of $\hbar_{eff}/\hbar = ZeV_E/f_S$ would be rather large of order $\hbar_{eff}/\hbar \sim 10^{19} \sim 2^{63}$.

5. Tesla argued that the magnifying transmitter generated telluric currents, which could propagate in the scale of Earth. The skin depth for Earth estimated from the resistance which is $10^{10} - 10^{12}$ times that of copper is in the range 4-40 km and from $j = \sigma E$ it is clear that also telluric currents decay exponentially with distance travelled so that Tesla's claim cannot hold true in Maxwell's electrodynamics.

One can however ask whether the currents could propagate as dark currents along magnetic flux tubes. In this case the damping would be very small and one can imagine current circuits in the scale of entire Earth. Also Schumann resonances at dark flux tubes would have very high Q-value as opposed to ordinary Schumann resonances whose Q-value (<http://tinyurl.com/yabm8yu5>) is estimated to be about 4 so that one fourth of the energy of the mode is lost during one cycle of duration 1/7.8 seconds.

10.6 Mysteries associated with lightnings, ball lightnings and the electrosphere of Earth

Lightning and ball lightning are electrospheric phenomena involving several poorly understood aspects. Also the origin of the electrosphere of Earth is still a mystery. In the TGD framework it is possible to deduce information about magnetic and electric bodies of Earth (briefly MB and EB) by using empirical inputs and these phenomena.

10.6.1 Basic facts

The following summarizes the basic facts about ball lightnings, lightnings, and the Earth's electrosphere.

1. Ball lightnings are known to be real are not understood. Ball lightning-like phenomena can be created also artificially in microwave ovens using match. Matches contain organic material and this serves as a good hint.
2. There is a New Scientist article, which gives a popular representation of ball lightnings (<https://cutt.ly/OHkW59F>).

The theory of Cameron [L156] is mentioned in the article. The theory assumes that lightnings are essentially phenomena associated with the electromagnetic radiation field alone and neglects the fact that plasma is very probably involved. The theory relies on exact solutions of Maxwell's equations and proposes that ball lightnings involve monochromatic electromagnetic fields which are knotted and linked making the field configurations topologically nontrivial. Both magnetic and electric field lines can be knotted.

This does not however imply topological stability since the linearity of Maxwell's equations implies that these field configurations are unstable. The finding that lifetime is long enough for microwave lengths does not conform with the fact that visible light is involved.

Another theory mentioned in the article is by Boerner and proposes that lightning comes from another dimension. What this could actually mean, is of course a highly non-trivial question.

3. The basic mystery is how ball lightning can survive for so long a time. An ordinary plasma ball is not expected to do so. This suggests that ball lightning obeys non-linear dynamics and is some kind of topological entity robust by their topological non-triviality.
4. A very natural expectation is that ball lightning is a self-organizing system consisting of plasma which radiates. Self-organization requires energy feed. It could come as a Coulombic energy from the electric field of Earth through which part of the plasma of ball lightning has arrived.

Here one encounters a problem. The electric resistance of the atmosphere causes a dissipation of the energy so that the charged particles cannot accelerate to high energies. How could lightning avoid this?

5. Two problems are always better than one. The second puzzle is that ordinary lightnings involve relativistic electrons and gamma rays [F10, F4] (for the TGD view of lightnings and related phenomena see [K24, K107, K9, K72, K133]). This is impossible in standard physics due to the already mentioned electric resistance of the atmosphere. Could ball lightning involve a new phase of matter, for which the dissipation is very small. Perhaps because it interacts very weakly with the ordinary matter of the atmosphere?
6. The third mystery is that the surface of Earth carries a negative charge, which creates an electric field. This field is essential for the generation of lightning. The origin of this field is however not understood.
7. There is also a fourth problem. Dark matter exists but there is no generally accepted theory of dark matter. All experiments trying to detect proposed candidates for dark matter particles (the particle physicist's way to solve a problem is to propose a new particle) have failed. There is of course also the mystery of life but it is better to stop here.

In the sequel a TGD based model for electrosphere is deduced by using various empirical inputs and the TGD based view about dark matter and the model of quantum biology inspired by it. A model, which allows us to understand these phenomena in the TGD framework, is developed. The model relies on the TGD based model of dark matter residing at the flux tubes of the magnetic body. The gravitational magnetic bodies of both Earth and Sun are important. The notion of the electric body of Earth as an analog of the cell membrane acting as a generalized Josephson junction is developed. Lightning and ball lightning would be associated with the analog of action potential.

10.6.2 The TGD view of ball lightning and other mysteries

What could TGD say about the mysteries associated with the Earth's electrosphere?

Dark matter in the TGD Universe

TGD predicts an entire hierarchy of phases of ordinary matter behaving like dark matter (and perhaps being the dark matter) in that they have very weak direct interaction with ordinary matter. These phases reside at the magnetic body (MB).

1. The notion of MB distinguishes between Maxwellian and TGD based views about electromagnetism. The flux tubes of MB can carry monopole flux which makes them topologically stable. Ball lightning could involve a tangle of a monopole flux tube carrying plasma and thus highly stable topologically. In fact, practically all structures in the fractal Universe of TGD would involve this kind of tangles: also galaxies and stars.
2. These phases are labelled by the value of effective Planck constant $h_{eff} = nh_0$, which can be larger than $h = n_0h_0$. The estimate for n_0 is given by $n_0 = (7!)^2$.

The larger the value of h_{eff} the longer the spatial and temporal scales of quantum coherence are, and the lower the dissipation rate is. In particular, ohmic resistance is reduced. Also the very weak interactions with ordinary matter reduce ohmic resistance for charged dark matter particles.

$h_{eff}/h_0 = n$ has an interpretation as the dimension of algebraic extension of rationals assignable with a polynomial defining the space-time regions at fundamental level [L90, L91]. It measures algebraic complexity and one could even speak about universal IQ. MBs with large value of h_{eff} would naturally receive information from and control the ordinary matter and represent higher levels in the master slave hierarchy of self-organizing systems.

3. The value of h_{eff} can be very large and one can assign it to the flux tubes mediating various kinds of interactions such as electromagnetic and gravitational, and even weak and color interactions.

Gravitational Planck constant $h_{eff} = h_{gr} = GMm/v_0$ introduced originally by Nottale [E2] is associated with flux tubes of a large mass M and particle with mass m . $v_0 \leq c$ is a parameter with dimensions of velocity and can have varying values. The gravitational

Compton length is given by $\Lambda_{gr} = GM/v_0$ and does not depend on m : this reflects the Equivalence Principle. Also cyclotron energies $E_c = \hbar_{gr} eB/m$ are independent of m .

Gravitational flux tubes would play a fundamental role in the TGD based quantum gravitational view about living matter. In particular metabolic energy would be stored at gravitational magnetic flux tubes with length scales given by Earth size as energy of dark protons. The delocalization of the dark proton to the surface of Earth would reduce the magnitude of gravitational potential energy.

This gravitational potential energy would be liberated as metabolic energy in a transition $\hbar_{gr} \rightarrow \hbar$ implying delocalization of dark. A correct value of metabolic energy currency is predicted [L129] if dark protons appear as triplets: ATP mechanism indeed involves proton triplets. Also a new metabolic energy quantum assignable to electron triplets is predicted and there is evidence for its necessity from the fact that cilia do not have ATP machinery but certainly need metabolic energy.

Pollack effect in cellular scales

What would drive particles, say protons, from ordinary matter to the MB and how would this be visible as properties of ordinary matter? The Pollack effect is a possible answer.

1. Pollack effect occurs in water bounded by a gel phase in presence of energy feed, for instance infrared (IR) radiation. Negatively charged regions, exclusion zones (EZs) are formed in water. They have a very high density of negative charge. As if every fourth proton of water would have left the region so that the effective stoichiometry is $H_{1.5}O$. Several exotic effects are associated with EZs.
2. EZs love cleanness and eliminate impurities from their interior. This does not conform with the second law of thermodynamics and can be seen as evidence for the reversal of the arrow of time.
3. As already noticed, the presence of gel phase and energy feed is needed to create EZs. This suggests that a primitive life form is in question. In biology both cell and DNA are basic examples of negatively charged regions which could be basically EZs.

The energies of particles indeed increase with \hbar_{eff} as a rule as it is easy to verify by looking at some examples.

1. The TGD explanation for the Pollack effect is that the energy fed to the system increases the value of \hbar to $\hbar_{eff} > \hbar$ for the protons and makes them dark particles at the magnetic flux tubes MB. If gravitational MB is in question, quantum gravitation would become a key player in quantum biology. The quantum gravitational model explains besides metabolism also bio-catalysis [L129] and allows us to understand how DNA could act as a topological quantum computer [L134].
2. The behavior of EZs suggests breaking of the second law of thermodynamics and therefore reversal of the arrow of time. In the TGD Universe the time reversal could occur in long scales at MB carrying phases with a large value of \hbar_{eff} . The basic prediction of TGD inspired theory of quantum measurement (extending to a theory of consciousness) indeed is that the arrow of time changes in the ordinary state function reduction (SFR), "big" SFR (BSFR) as it is called in TGD. In "small" SFRs (SSFRs), which are counterparts for "weak" measurements, the arrow of time is not changed.

Pollack effect in the scale of Earth

The surface of Earth is known to be negatively charged so that Earth has an electric field.

1. The electric field strength has a nominal value $V_E = 120$ V/m and varies in the range 100-300 V/m, as one can for instance learn from the excellent lectures of Feynman (<https://cutt.ly/OHkAWFs> or from Wikipedia <https://cutt.ly/PHkACG2>).

The number density dn/dA of unit charges e per unit area would be about $(137/4\pi)eV/m = (137/4\pi)10^8/m^2$ making one unit charge per area corresponding to the size of a large neuron about 10^{-4} m. This volume of water happens to have a mass about 1 Planck mass.

2. The field extends to the height of about $h_E = 50$ km at which height the conductivity of the atmosphere is so high that the electric field vanishes in good approximation above this height. The voltage at this height is about $V_E = 5 \times 10^5$ V. There must be a layer of positive charge concentrated at this height and neutralizing in a good approximation the positive charge so that electrosphere would contain structure analogous to a pair capacitor plates. Note that ionosphere begins at height of about 48 km.
3. The origin of the Earth's electric field is not known but it is known to be relevant for life.

The fractality of the TGD Universe suggests that the Pollack effect can be realized also in the Earth scale. The dark part of the magnetic field of Earth involving monopole flux tubes could carry dark protons and possibly also other dark particles. This would create the electric field of Earth. One could see the biosphere as a living organism, Mother Gaia.

1. If the Pollack effect takes protons to the (gravitational) MB of Earth, Earth becomes negatively charged and creates an electric field. One dark proton per size scale of a large neuron (water blob having roughly Planck mass) would be transferred to the (gravitational) MB of Earth.
2. The energy of a unit charge received as it travels from the height of $h_E = 50$ km to the surface of Earth without ohmic resistance of 5×10^5 eV, which corresponds to electron mass. Electrons travelling from Earth upwards would gain relativistic energy in this field. Protons travelling downwards would gain the same energy. The photons radiated by accelerated electrons and protons would have gamma ray energies. This would explain the association of relativistic electrons and gamma rays to lightning.
3. Most of the screening positive dark charge should reside at the height of about $h_E \sim 50$ km. The magnetosphere of Earth has a much larger size of about $10R_E$ at the day-side of Earth. This suggests that the densities of the dark charged particles (at least protons and electrons) sum up to zero at higher heights.

The natural option is based on the approximation that the space above h_E is a perfect conductor. In a perfect conductor the surface charge indeed prevents the penetration of the external electric field inside it.

The dark protonic charge from hydrogen bonds and possibly also dark electronic charge would basically screen the electric charge of Earth at higher heights of order Earth radius.

4. What could the dark positive charge at the height h_E consist of? One could consider dark protons but also dark ions at the oppositely charged boundaries of the conductor. Dark ions play a key role in the TGD based view of quantum biology. They could be metal ions for which the valence electrons are gravitationally dark and at similar U-shaped vertical flux tubes as the dark protons of H bonds [L129].

Why just the height h_E ?

1. p-Adic length scale hypothesis $p \simeq 2^k$ [K69] favours Mersenne primes $M_k = 2^k - 1$ (k is prime) and their Gaussian analogues $M_{G,k} = (1+i)^k - 1$. Could $h_E = 50$ km correspond to Gaussian Mersenne? The answer is negative. The corresponding p-adic length scale is proportional to $\sqrt{p} \propto 2^{k/2}$. The twin pair $(k_1, k_2) = (239, 241)$ defines a pair of Gaussian Mersennes. $M_{G,151}$ corresponds to cell membrane thickness $L(151) = 10^{-8}$ m and $L(239)$ is scaled by a factor $2^{44} \simeq 1.6 \times 10^{13}$ to $L(239) \simeq 160$ km, that is $3h_E$, $h_E = .5 \times 10^5$ km.
2. The idea that Gaussian Mersennes define fundamental lengths is too beautiful an idea to be given up too easily. The ionosphere extends from 48 km to about 960 km. Thermosphere extends from 90 km to 500 km.

Could one think of a conductor-like structure with thickness $L(241) = 320$ km with boundaries at $h_E = 50$ km and $L(241) = 320$ km extending from $h_E = 50$ km to $h_{E,1} = 410$ km and having a vanishing total charge so that above this distance Earth would look negatively charged and carry electric field, whose strength would be scaled down from its value at the surface of Earth by a factor $(R_E/(R_E + h_{E,1}))^2 \sim 1$.

3. One can argue that this field would have been observed long ago so that the conducting region must extend much farther. Despite this objection, one can ask whether these layers could exist and correspond to membrane-like preferred extremals, which are minimal surfaces in $H = M^4 \times CP_2$. Note that the E^3 projection is not minimal surface but analogous to a soap bubble [L121]. Also the cell membrane would be accompanied by this kind of pair of surfaces and magnetic flux tubes would traverse it.
4. TGD predicts that any astrophysical object necessary has a non-vanishing but arbitrarily small Kähler charge, which is accompanied by electromagnetic charge. The reason is that a long range gravitational field defined by the induced metric unavoidably implies a long range Kähler electric field.
5. One can argue that this electric field would have been observed so that the conducting region must extend much farther. Despite this objection, number theoretic intuitions give the right to ask whether these layers could exist and correspond to membrane-like preferred extremals, which are minimal surfaces in $H = M^4 \times CP_2$. Note that the E^3 projection is not minimal surface but analogous to a soap bubble [L121]. Also the cell membrane would be accompanied by this kind of pair of surfaces and magnetic flux tubes would traverse it.
6. If dark ions of opposite charges (perhaps as pairs of a dark metallic ion and valence electrons) reside at the proposed layers with the distance $L(241)$, they could correspond to dark ionic matter that I have assigned with the MB of Earth. As a matter of fact, one could say that they reside in the electric body of Earth defined by the boundaries of this conductor. Could this pair define the analog of the double lipid-layered cell membrane and could the Earth itself define the analog of a cell nucleus? DNA is negatively charged and is responsible for the negative charge of the cell nucleus and perhaps of the entire cell. What could this analogy suggest in the case of Earth?

In the TGD Universe, one can ask whether the Earth is a living organism, Mother Gaia as an analogy of a monocellular organism but in the scale of Earth.

1. The capacitor plates would define the analog of a cell membrane having membrane potential 5×10^5 eV, which is 10^7 times higher than the membrane potential $V \sim .05$ eV and corresponds to electron rest mass. Also monocellulars can exhibit action potential and lightning would be its analog. Ordinary cells form dark (generalized Josephson junctions). For them ohmic currents are replaced with oscillating Josephson currents with Josephson frequency $f_J = eV/h_{eff} \simeq m_e v_0/GMm$.

One can also imagine a gravitational Josephson current defined by the gravitational potential of the Earth. In this case the energy scale is about eV. In the electric case it is 10^7 times higher.

2. For $M = M_E$, $v_0 = c$ and $m = m_p$ this would give $f_J \simeq 10^5$ Hz, which is not far from the cyclotron frequency of electron in the endogenous magnetic field $B_{end} = .2$ Gauss deduced from Blackman's findings [J31] and identified as the monopole flux part of the Earth's magnetic field B_E with the nominal value .5 Gauss.
3. Also solar gravitational MB is important in the model and the model of photosynthesis and ATP involves it in an essential manner [L129]. For Sun with $M_S \simeq 3 \times 10^5 M_E$, $v_0/c \simeq 2^{-11}$ and $m = m_p$, Josephson frequency would $f_J \simeq 1$ Hz. This is the average value for DNA cyclotron frequency in B_{end} , which only weakly depends on the length of the DNA strands since the nucleotides have a negative unit charge.

Since the cyclotron transitions would be associated with dark ions with $h_{eff} = h_{gr,Earth}$ and f_J would correspond to Josephson radiation associated with $h_{gr,Sun}$, it would seem that

Josephson radiation induces cyclotron transitions. This would be communication between solar and terrestrial levels of the dark matter hierarchy? Could solar level control the terrestrial level?

Models for lightning and ball lightning

The model for the ball lightning would be as follows.

1. Lightnings would involve the transfer of dark matter to the surface of Earth and they could arrive to the surface of Earth along gravitational flux tubes. Just like action potential, lightning would correspond to a local breakdown of superconductivity. Ball lightning could be born at flux tubes sy heights below h_E and generate plasmoids as primitive life forms.
2. The large value of h_{eff} and topological stability of monopole flux tubes would explain the long life time of ball lightning.
3. The self-organization of living matter would produce via the Pollack effect plasmoid-like negatively charged systems in microscales. Ball lightning could be seen as an analog of a cell. It would also have the counterpart of the cell membrane and a good guess is that its thickness is scale for .5 m sized ball lightning to .5 cm which happens to be one half of the Swartshild radius of Earth which defines the gravitational Compton length. Whether ball lightning is negatively charged can be tested if it can be produced in a microwave oven.

Is the proposal consistent with the model of metabolism based on quantum gravitation?

One can worry about the consistency with the dark gravitational model of metabolism [L129].

1. The quantum gravitational model of metabolism gives an estimate for the height of the metabolic dark protons. If the dark protons at a U-shaped flux tube correspond to a stationary orbit in the gravitational field of Earth, the height from the Earth's surface would be about $h_g = 1.5R_E$. For proton triplets one obtains the correct value of the metabolic currency. The strong electric field near the surface of Earth would correspond to a rather short length scale as compared to this scale. The ratio $h_E/h_g \simeq 5 \times 10^{-3}$ is rather small. The gravitational potential energy difference is scaled roughly by this factor downwards so that the protons at this height cannot liberate metabolic energy quantum as gravitational potential energy.

TGD assigns to electrons metabolic energy quantum which is by factor m_e/m_p smaller than the standard metabolic energy quantum by factor of order 1/10 smaller than the protonic gravitational energy liberated at height h_E .

Most of the screening dark protons would be at a height which is much smaller than the height at which the gravitational potential energy is of order .5 eV for metabolic energy currency. This is possible since the scale of MB of the Earth is about $10R_E$ at the day-side.

2. The electric field is in good approximation given as a gradient of potential and the voltage between points A and B is same alon all space-time sheets. Therefore the voltage should be the same also along the gravitational flux tubes if they connect A and B. Does this mean that gravitational dark protons coming from higher heights than 50 km receive huge energy of about electron mass m_e .

The metabolic dark protons at the gravitational flux tubes should be able to avoid this electric field: otherwise they would have energy of order m_e . How? One can imagine 4 options.

1. The proposal of [L129] is that the transformation $h_{gr} \rightarrow h$ for dark protons involves a reconnection of the gravitationally dark flux tube with flux tube having much smaller value of h_{eff} and also accompanying dark hydrogen bond. If these flux tubes extend to a height somewhat larger than $h = 50$ km, the acceleration could be avoided by reconnection and staying at this height. The gain of metabolic energy communicated to the surface of Earth by dark photons would be essentially the same. The naive estimate for the value of h_{eff} for these flux tubes would be $h_{eff}/h_{gr} \sim h_E/R_E \sim 1/100$.

2. The presence of solar gravitational MB was proposed in [L129]. In this case the gravitational Compton length would be $\Lambda_{gr} = GM_S/v_0$, $v_0 \simeq 2^{-11}$. This would correspond to the scale of 6×10^6 m, to be compared with Earth's radius $R_E = 6.4 \times 10^6$ m! Also in this case the reconnection would make it possible to avoid the acceleration in the electric field.
3. The model of genetic code also requires both dark protons and dark neutrons [L141, L129]. Dark neurons are possible if strong and weak interactions are dark and thus are not screened below the Compton length of the bosons mediating them. This means a scaling of their typical length scaled up by h_{eff}/h : for weak bosons and for h_{gr} , the scale would be GM/v_0 and about .45 cm for $M = M_E$ and about R_E for $M = M_S$.

The dark nucleon sequences at the flux tubes would be dark nuclei, which in the TGD based model are indeed string-like entities [L3]. Dark neutrons could propagate through the electric field without acceleration. Dark weak bosons would be effectively massless below the scaled up weak scale and this could explain chiral selection in living matter, which is very difficult to understand in the standard model.

4. If the gravitational portions of the flux tubes through the analog of the cell membrane act as Josephson junctions, the energy would not be dissipated as for Ohmic currents. There would be only a rapidly oscillating current with Josephson frequency. For the solar gravitational flux tubes the oscillation frequency would be about 1 Hz. It is not clear to me whether this could solve the problem.

10.7 Pollack effect, lightnings and ball lightnings

Ball lightning (see this) is a phenomenon challenging the standard physics. Years ago I wrote about ball lightning and identifying it as a plasmoid, a kind of a primitive life form analogous to a cell. When I learned from the experimental and theoretical work done during this millennium and decided to sharpen my views.

The analogs of ball lighting can be produced in laboratories in strong electric fields using an electric discharge from carbon electron to silicon wafer [D21]. Pure silicon is very rare in nature and appears in the forms of Si oxides, silicates, in particular SiO_2 (see this). Quartz crystals and glass consist of silicon dioxide. In the experiment involving a silicon wafer the globules are divided into two groups: those having sizes in the range .2-.8 mm (high voltages) and .8-1.4 mm (low voltages). The sizes of ball lightning vary from a few millimeters to about 100 cm.

In DC voltage, the wafer decomposes to globules of various sizes. They can last as long as 6-8 second unlike sparks. The proposed explanation is that the globules are evaporated Si. Larger globules have at their surface silicate oxide assumed to be formed in the interaction with air. Larger balls have tube-like extrusions and smaller balls at their surface. They can also rotate and bounce: the energy should come from their decay as an exogenic process. There is evidence for the self-propulsion which brings in mind the motion of bacteria using cilia [D31].

Leo Vuyk has an article about these ball lightning-like objects containing a large number of illustrations (see this).

The theoretical proposal is that ball lightning [D33] (see this) is formed as the lightning strikes on the soil and SiO_2 crystals evaporate and transform to Si and Oxygen. There is support for this from direct observations of the spectrum of ball lightning containing spectral lines assignable to the elements in the soil. The spectra associated with ordinary lightning do not contain similar lines. How the chemical reaction producing Si and O_2 ions from SiO_2 ions could take place is far from clear. A lot of energy is needed for this process to occur. Where does this energy come from?

There is also the so-called microwave theory of ball lightning. Microwave wavelengths vary in the range of 1 mm-30 cm as also the sizes of ball lightning. The ball lightning would correspond to microwave cavities with a dynamical size and shape.

In the sequel a TGD inspired model for the ball lightning-like structures in silicon and for the real ball lightnings is developed relying on the TGD view of space-time predicting fractality and inspiring the hypothesis that biosphere could be regarded as a system analogous to neuronal membrane and that lightnings could be analogous to nerve pulses, the identification of dark matter as phases with non-standard value of Planck constant allowing quantum coherence in arbitrarily

long scales, the TGD view of quantum gravitation and its role in quantum biology [L129, L125], and the TGD inspired model of nerve pulse [L158].

10.7.1 TGD view of lightnings

The background for the TGD based model of lightnings and ball lightnings is provided by the TGD view of magnetosphere [K67, K65] [L104] that I have developed during the last decades. The magnetic bodies (MBs) of living systems and even the MB of the biosphere would be controlling agents. These MBs are predicted to have a hierarchical onion-like structure [L151, L152] (monopole flux tubes inside monopole flux tubes). They would carry dark matter as phases of the ordinary matter labelled by the value of effective Planck constant having a number theoretic interpretation. EEG and its possibly existing scaled variants would make possible the communications to and control by these MBs.

The TGD based view of ball lightning relies on the fractality of the TGD Universe suggesting fractality also at the level of the biosphere. This inspires the notion of the biosphere as an analog of the cell membrane. The TGD view of nerve pulse [K96] and its up-to-date version [L158] inspire the idea that lightning is a scaled up variant of nerve pulse.

Biosphere as analog of neuron

The fractality of the TGD Universe inspires the idea that the Earth ground-atmosphere pair as an analog of neuronal interior-exterior membrane. The background for this discussion is formed by the TGD view of magnetosphere [K67, K65] [L104]. The magnetic bodies (MBs) of living systems and even the MB of biosphere would be controlling agents. These MBs would have a hierarchical onion-like structure [L151, L152].

1. The Earth ground-atmosphere pair is analogous to the cell interior-cell exterior pair. The surface of the Earth is negatively charged and analogous to the cell interior. This negative charge creates an electric field of strength 100-300 V/m (see this). The height h for the clouds varies in the range .5-16 km. For a cloud at height of 10 km this corresponds to an electrostatic energy .1 – .3 MeV and for $h=16$ km one has .48 MeV. In the case of electrons with rest mass of .5 MeV, these energies are relativistic and could relate to the observed relativistic energies associated with the lightning.
2. The thunder cloud (see) has a positive charge near the top of the cloud and negative charge in the middle to lower part of the thunder cloud. At bottom there is a small positive charge known to be important. The negative charge of the cloud repels the negative charge at ground so that ground becomes positively charged below the cloud. Does this induce a local depolarization of the ground-cloud system as the analog of cell membrane?

This raises an objection against the idea that dark protons are at gravitational monopole flux tubes and that their energies are of the order of the gravitational binding energy in the gravitational field of Earth of order .5 eV. If dark protons experience the Coulombic force of Earth, their Coulomb energies are in the range .8-2.4 MeV below the ionosphere at height $h_I = 80$ km, which defines the minimum height of the lower boundary of the ionosphere. The problem disappears since the dark protons at monopole flux tubes are at much larger heights, where the electric field of the Earth vanishes. However, the dark matter at parts of the MB at heights smaller than h_I the electric energy dominates and their role in biology should be very different.

3. Neuronal membrane is hyperpolarized and the nerve pulse is initiated when depolarization takes the membrane potential below a critical value. Could lightning be seen as an analog of nerve pulse induced when cloud-ground depolarization takes place? Thunder storm would be analogous to a conduction of a nerve pulse pattern.

TGD view of nerve pulse

The TGD based model of nerve pulse [L158] relies on the Pollack effect inducing a charge separation between cell interior/exterior and its MB.

1. Pollack effect [I126, L25, ?, ?] occurs in water in the presence of a gel phase. Also energy feed is required and in standard Pollack effect solar radiation provides it. The Pollack effect generates what Pollack calls the fourth phase of water. It has the effective stoichiometry $H_{1.5}O$ and every fourth proton of water has gone somewhere. In the TGD based model they would transform to dark protons at the gravitational MB of the Earth.
2. Pollack effect inside the cell would generate negatively charged EZs making the cell negatively charged. The dark protons would reside at the gravitational MB of Earth having astrophysical size and are therefore effectively outside the system. The negative charge of EZs induces positive polarization charges in the cell exterior. The properties of EZ suggest that second law holds in a reversed time direction and large scale quantum coherence zero energy ontology (ZEO) [K146], predicting that the arrow of time changes in the ordinary state function reductions, can explain this.
3. In the nerve pulse generation, the reverse Pollack effect would occur and neutralize the negative charge of the cell interior locally [L158]. This would induce a local depolarization. The reverse Pollack energy generates dark photons and is received by the water in the neuron exterior. This would induce Pollack effect in the cell exterior and generate a negative charge as EZ outside the cell so that membrane potential would change its sign temporarily. An effective charge transfer induced by the Pollack effect and its reversal occurs: a kind of quantum flip-flop is in question. The possibly Ohmic ionic currents associated with the nerve pulse are generated as a consequence but could be seen as a side effect rather than a cause of the nerve pulse.
4. In zero energy ontology (ZEO), nerve pulse corresponds to two pairs of BSFRs ("big" state function reductions) corresponding the reduction of membrane potential to its negative and the reversal of this process [L158]. Each pair involves a temporary change of arrow of time: this would conform with the formation of EZs.

Lightning as an analog of nerve pulse?

Could lightning and nerve pulse be generated by the same mechanism?

1. The fractality of the TGD Universe inspires the proposal that the Earth's biosphere and its MB [K67, K65] [L104, L151, L152] are analogous to a cell membrane or even neuronal membrane or possibly a collection of basic units analogous to those of neuronal membranes. In the lightning strike, a charge separation between ground and its MB would transform to a charge separation between cloud and its MB. Lightning would be induced by the depolarization just as in the case of neuronal membrane.

The assumption distinguishing sharply between TGD and standard physics is that the primary charge separation does not occur between cell interior and exterior but between interior/exterior and its MB.

2. In the initial, rather stationary situation, the Pollack effect at the ground has generated EZs and made the Earth surface negatively charged. The electric field of the Earth gives rise to the analog of the resting potential of neurons as the voltage between ground and (say) the cloud. Negatively charged EZs at the ground induce the small positive charge (known to be important) at the bottom of the cloud by polarization.
3. The reverse Pollack effect would occur at the ground and partially neutralize the negative charge of the ground locally and induce a local depolarization. The energy transfer by dark photons to the cloud would induce Pollack effect in the cloud generating negatively charged EZs and lead to a local depolarization in the cloud, which effectively looks like a transfer of negative charge to ground. This would change the sign of the electric field locally or at least reduce its strength.

A moving thunderstorm accompanied by lightning strikes would be analogous to the nerve pulse conduction. The ion currents between cloud and ground are analogs of various ionic

fluxes during the nerve pulse. Both oscillating Josephson currents along the gravitational monopole flux tubes and Ohmic currents are possible.

Also nerve pulse conduction would be seen as a temporal sequence of local lightning at discrete positions at discrete times. This conforms with the TGD based model for nerve pulse in terms of propagating Sine-Gordon solitons associated with a sequence of effective mathematical pendulums [K96] [L158].

It would be interesting to relate the parameters of nerve pulse conduction (say conduction velocity) to the parameters of the propagation of thunderstorms. Also the parameters corresponding to those appearing in the TGD based model of nerve pulse in terms of Josephson junctions and dark Josephson currents would be highly interesting. The dream would be a quantum model for a thunderstorm.

Biosphere as a Josephson junction

What could the identification of the biosphere as a Josephson junction or collection of them could mean? Consider first the neuronal membrane [L158].

1. In the case of the neuronal membrane, one has a collection of Josephson junctions defined by monopole flux tubes assignable to membrane proteins believed to act as channels and pumps. This collection can be idealized with a continuous Josephson junction with the phase difference associated with supra phases at the two sides obeying Sine-Gordon equation [K96].
2. The Coulomb energy $E_J = ZeV$ allows an interpretation as a Josephson energy of charge Z (say Cooper pair with $Z = 2$). For $\hbar_{eff} = \hbar_{gr}GMm/\beta_0$ the corresponding frequency is $f_J = ZeV/\hbar_{eff}$. This frequency depends on the mass m of dark charge assignable to gravitational monopole flux tubes. M could correspond to some large mass, such as the mass of Earth, Sun, or Moon.
3. The generalized Josephson energy assignable to the junction is assumed to be sum of E_J and of the difference of cyclotron energies assignable to the flux tubes arriving to the cell membrane from the cell interior and exterior. The difference of cyclotron energies would give the dominating contribution to the generalized Josephson energy and would be equal to the cyclotron energy at the gravitational magnetic body. For this option, ordinary Josephson energy would code membrane potential oscillations and even nerve pulse to a small modulation of the generalized Josephson energy and - frequency.
4. At the gravitational MB, assumed to be an onion-like structure consisting of nearly spherical layers [L151, L152], cyclotron resonance must occur in the receipt of the dark Josephson radiation. The condition for this is that the dark cyclotron energy $E_c = \hbar_{gr}ZeB/m = GMZeB/\beta_0$ (by Equivalence Principle, there is no dependence on m) is equal to the generalized Josephson energy.
5. If there is no cyclotron contribution to the generalized Josephson energy, it reduces to the ordinary Josephson energy $E_J = ZeV$ and the resonance condition implies that M must correspond to the mass $M_M \simeq 1.02M_E$ of the Moon! [L158].

This does not occur if the cyclotron contribution dominates and the cyclotron resonance condition can be satisfied for M_E and the variation of membrane potential is coded to a sequence of resonances analogous to a sequence of nerve pulses. Nerve pulse patterns could indeed be preceded as a reaction of the MBs of sensory receptors to dark Josephson radiation.

Could this picture of the cell membrane as a Josephson junction generalize to the recent situation?

1. Suppose that also in the recent case the generalized Josephson energy involves the difference of dark cyclotron energies besides the ordinary Josephson energy and that it dominates. Suppose that one replaces the mass M , say the mass of Earth, appearing in \hbar_{gr} by the mass M_S of say Sun. Assume that the Earth's mass appears in \hbar_{gr} for neurons.

2. If the membrane potential scales as $V \rightarrow (M/M_E)V$, the resonance conditions remain true since they do not depend on M at all. This would extend the Equivalence Principle so that it would apply to both M and m . Neuronal membranes could couple to the gravitational MBs of both Sun, Earth and even Moon.

The scaling factor of V would be $M_S/M_E \simeq 3 \times 10^5$ and in the case of membrane potential would give $V = .05 \text{ eV} \rightarrow V = 15 \text{ keV}$. The height h of the thunder cloud varies in the range $[.5, 16] \text{ km}$. The ratio h_{max}/h_{min} of the maximum and minimum heights is $h_{max}/h_{min} = 32$, which is a power of 2 and brings in mind p-adic length scale hypothesis.

Note that the scaling down by M_{Moon}/M_E would give $V = .5 \text{ meV}$, which corresponds to the scale of miniature membrane potentials modulating neuronal membrane potential.

3. The ratio of the maximum and minimum electric fields strengths is roughly $E_{max}/E_{min} = 3$ and considerably smaller than the ratio $h_{max}/h_{min} = 32$ so that the correlation between E_{max} and h is weak. In the absence of a correlation between E and h , and at the height of 10 km, the range would be $[.1, .3] \text{ MeV}$. A cloud at height of $h = 16 \text{ km}$, which is also possible, corresponds to an electrostatic energy in the range $[3.2, 9.6] \text{ MeV}$.

As noticed, this model can explain the relativistic electron energies assigned with the lightning. The electrons would propagate along monopole flux tubes with a large value of h_{eff} and dissipation would be absent.

There are many interesting questions to be answered.

1. Both the cell membrane and ionosphere can be seen as a capacitor like system or battery. The lower boundary of the ionosphere is at the height h_I between 80-600 km. Ionosphere contains a layer of electrons and can be seen as an analog of negatively charged conductor plate of a capacitor formed by the positively charged Earth surface and ionosphere. Radio waves are reflected back from the ionosphere. Schumann resonances are associated with it.
2. Neuronal membrane corresponds to the p-adic length scale $L(151) = 10 \text{ nm}$ and its lipid membranes to $L(149)$. $L(151)$ corresponds to Gaussian Mersenne. Can one assign a Gaussian Mersenne also to the ionosphere?

After the Gaussian prime $G(167)$ defining p-adic length scale of $2.5 \mu\text{m}$, size of cell, the next Gaussian Mersenne is $G(239)$ and corresponds to $L(239) \simeq 160 \text{ km}$ and has $G(241)$ as Gaussian twin prime. 160 km is roughly the height of the lower boundary of the F region (ionosphere decomposes to D, E, and F regions and the electron density is highest in the F region).

The scale of 80 km is one half of $G(239)$ brings in mind lipid layers of the cell membrane to which one assigns capacitor plates. Could one think that the crust of Earth with thickness between 4.7 and 69 km defines the analog of the second capacitor plate.

3. In the cell membrane, the transversal scale of channels and pumps is about 10 nm and corresponds to the p-adic length scale $L(151)$ and the same as cell membrane thickness. What could be the counterparts of the membrane proteins assumed to be accompanied by Josephson junctions?

Thunder storms (see this) are known to decompose to cells. Either these cells or thunder clouds could correspond to the basic units of cell membrane with the size scale $L(151)$. In the TGD based quantum view of hydrodynamics [L115], these structures would be hydrodynamical vortices (such as tornadoes) accompanied by monopole flux tube structures.

Thunder clouds are at heights varying in the range $[.5, 10] \text{ km}$ and the height and diameter of clouds is 10-20 km. Could this scale or the size scale of the cell correspond to the size scale of the basic unit of cell membrane and therefore to $L(239)$. This scale is however several orders of magnitude smaller than $L(239)$.

10.7.2 Ball lightning in the TGD framework

Could one understand the generation of ball lightning in this framework?

1. Suppose that in the normal situation the Pollack effect [I126, L25, ?, ?] for the water at the soil has somehow generated EZs and SiO_2 ions from Si and water of the soil or atmospheric oxygen. This would explain the negative charge of the ground. The Pollack effect would not require energy feed now since the binding energy liberated in the formation of SiO_2 crystals would take care of energy conservation. A situation in which part of water corresponds to $\text{H}_{1.5}\text{O}$ ions would be energetically favored.

Note that this mechanism could be very general and make possible a quantum gravitational control of molecular transitions with binding energies in eV range. This would make it possible to establish plasma-like state typical for electrolytes by the Pollack effect and also induce a temporary decay of the biomolecules by the reverse Pollack effect providing the energy making it possible to overcome the energy barrier. This would be essential for biocatalysis.

2. In the reverse Pollack effect associated with the lightning strike, dark protons from MB would transform ordinary protons and return to the ground. The liberated energy would make possible the decay of SiO_2 molecules to Si and O_2 . Ordered water would transform to ordinary water getting its oxygen ions from SiO_2 .
3. This situation is not energetically favored. The Pollack effect would take place and lead to the original situation in a time scale of a few seconds. The slow time scale could relate to the large value of \hbar_{gr} . The liberated gravitational binding energy in the Earth's gravitational field for a single dark proton is below .5 eV, which corresponds to the nominal value of metabolic energy currency [L129, L125].

Note that the counterpart of the membrane potential energy $E = eV$ is in the recent case in the range .1-30 MeV and much higher than the scale of the molecular binding energies. These energies are consistent with the finding that gamma rays accompany lightning strikes.

Connection with crop circles, UFOs, and glass balls in the Moon

A connection with crop circles is highly suggestive. I have discussed crop circles from the TGD point of view in [K41, K40] in a rather speculative spirit but starting from empirical facts published by professional biologists. There are reports that the crop circle formation occurs in presence of light balls analogous to ball lightning. The formation of crop circles can be understood in terms of the interaction of microwaves with crop stems causing effects similar to those taking place as one puts a tomato in a microwave oven. The size scale range for ball lightning conforms with the wavelength range for microwaves. Therefore the microwave theory seems to be consistent with the model based on the Pollack effect. The light ball would be an analog of the nerve pulse in the scale of the biosphere.

Meteorite iron is found at crop circles: they could arrive from the gravitational MB along gravitational flux tubes. Also small glass balls, encountered also on the Moon, are reported. They could emerge in the transformation of Si and O_2 to SiO_2 as the Pollack effect takes place.

What is fascinating is that crop circles look like intentional constructs expressing discrete geometric symmetries. Could the plasma balls be intelligent conscious entities, a new kind of life form and could they represent the primordial life forms, kind of proto cells? This kind of plasma balls are also reported in UFO encounters. Systematic observations of the plasma balls are performed in Hessdalen and the plasma balls are reported to behave like intelligent and intentional entities.

The gravitational MB of these entities would correspond to that of the Sun. Could this mean that their theoretical IQ, defined by the gravitational Planck constant of the Sun, is dramatically higher than ours? Probably this is not the case: the gravitational Compton frequency for the Sun is around 50 Hz. This is the cyclotron frequency of Lithium for $B_{end} = .2$ Gauss. It is known that too low Li depletion in the soil tends to induce depression and suicidal behavior. 50 Hz corresponds to EEG frequency so that life forms with EEG would interact with the gravitational MB of the Sun.

Are we silicon based life forms?

Computationalists tend to think that silicon based life will emerge in future. However, if the above considerations make sense, Si, chemically similar to Carbon and appearing as quartz in soil, could

play a central role in life already now! Maybe the people claiming that quartz have very special effects on the state of consciousness, are right. In fact, I have had an opportunity to experience these effects myself.

Intriguingly, molten silica shows several characteristics observed in liquid water (see this) and the amorphous glass phase of silica resembles liquid in many aspects.

Interestingly, silicon di-oxide is used in MOSFETs. In [L148, L147], I have considered a model for how ordinary computers could become conscious entities. This requires the failure of statistical determinism in long enough time scales. The proposed condition would be that the gravitational Compton frequency 67 GHz for Earth (microwave wavelength), which corresponds to a wavelength of $.5$ cm for Earth (the size scale of a snowflake), is longer than the clock frequency. This condition is not quite true for recent computers.

If ordinary computers can be conscious, the properties of MOSFETs must be in a crucial role. Is this possible?

1. The SiO_2 in MOSFETs could have a glassy, spin glass-like structure to give them high representative capacity and there is some evidence for this. The transistors should also define Josephson junctions. The alternative, more promising option, discussed in [L147], is that the conscious computer is based on the representation of bits in terms of Josephson junctions.
2. MOS is obtained by growing a layer of Si on top of SiO_2 . However, the idea about the local transformation of SiO_2 to Si and O_2 with Si in vapour phase by an analog of the Pollack effect does not look plausible since protons are not available now.

Electrons should be transformed to dark electrons at the gravitational MB of Earth and the formation of SiO_2 would make possible energy conservation. The transformation of electrons back to ordinary electrons liberates energy and should induce the decay of SiO_2 . The needed energy is few eVs. However, the gravitational binding energy for electrons in the field of Earth has an upper bound of order $.25$ meV. Note that the melting temperature of SiO_2 corresponds to the energy $.134$ eV. It seems that the only possibility that one can imagine is provided by dark variants of quantum coherent many-electron states.

10.8 Tesla's Work, Biology, And TGD

If TGD world view is correct, remote metabolism could also have technological implications. Three different applications mimicking biology come in mind. The communication with geometric past by sending negative energy photons and receiving positive energy photons - as memory recall and remote sensing; the initiation of motor actions by sending negative energy signal to geometric past; and remote metabolism. Zero energy ontology justifies these ideas.

Energy is the bottleneck of recent day technology. Nuclear energy has well-known problems. Also the use of, say, oil as a fuel produces environmental problems and for long travels - in particular space travel - the needed amount of fuel poses an insurmountable problem. The storage of energy as electric energy has also its difficulties due to the fact that the lifetimes of accumulators are very limited.

Tesla had surprisingly far reaching vision about the means of generating and transferring energy in the future society. Tesla speculated about an analogy with biology: in future technology the energy user would extract energy from environment and do this only when it needs the energy. Tesla also believed that there exist unidentified energy sources. This does not imply their identification with zero point energy (ZPE) as often erratically claimed - ZPE emerged as an outcome of quantum field about which Tesla knew nothing. Tesla also speculated on a connection to biology.

To me the most amazing and perhaps most important finding reported by Tesla is what he called "cold electricity" and as a child of his time interpreted it as an evidence for aether particles and scalar photons. What is amazing is that in TGD framework the reported properties of cold electricity and aether particles suggest an interpretation as Cooper pairs of dark electrons and dark photons (recall that we *know* that dark matter is there!). If this is really the correct interpretation, dark matter would have been discovered more than century ago!

In the sequel I will discuss a simple formula expressing the conditions for the transition to a phase that Tesla called "cold electricity", identified in TGD framework in terms of dark matter

- and study its generalization to the case of cell membrane allowing to deduce formulas relating cell membrane critical potential and p-adic length scale assigned to given dark particle. These formulas are of course only guesses based on general principles and on available numbers. If the proposed general principles are not correct, one can forget the formulas!

10.8.1 Tesla's Work

In this section Tesla's work about energy transmission and cold electricity are briefly discussed. After that TGD inspired interpretation of the findings is discussed.

Tesla's vision about energy transmission

Probably already Tesla (see <http://tinyurl.com/yysaqzm>) realized the deep problems related to energy and Tesla's technology based on alternative currents initiated by the discovery of AC magnetic motor became the basis of the modern society and the transfer of information by radio waves the standard.

Tesla's vision was that not only information but also energy could be transmitted as radiation and this served as his motivation in transmitter experiments. The idea (<http://tinyurl.com/28nbnr>) [H3] was that the energy beam sent to what is now known as Kennelly-Heaviside layer is echoed back and received by the user. The objection against the transfer of energy by radiation is obvious. In Maxwellian world the radiation from energy source propagates to all directions and the power density decreases as $1/r^2$ with distance. Only a small fraction of radiative energy can be used.

One can of course consider a situation in which geometric optics applies reasonably well: this requires however that the wavelength used is small as compared to the size of the antenna. For 200 kHz corresponding to the highest frequency used by Tesla the wavelength is about 1.5 km. For smaller wavelengths one cannot anymore assume that the radiation is reflected from the upper boundary of Kennelly-Heaviside layer.

To develop this vision Tesla studied so called Tesla transmitters (<http://tinyurl.com/y778g5sg>) and magnifying transmitters (<http://tinyurl.com/y7yybrpf>) [H3], which instead of serving as voltage transformers acted as amplifiers: the primary circuit acted as a resonant driving force so that an energy transfer to the secondary was achieved. These circuits act as both receivers and antennas. The circuits applied dynamic switches based on the di-electric breakdown of the surrounding air and generated in the secondary di-electric breakdowns through surrounding air to surprisingly long distances. Rather interestingly, the duration of resonant period after di-electric breakdown putting the switch on was few milliseconds which is the time scale associated with nerve pulse. I do not know whether anyone has really explained this coincidence. Also the frequency range studied was 20-100 kHz which corresponds to biological time scales. Tesla discovered in his experiments X rays assignable to the high voltages generated in the Tesla transformer.

Tesla also generated radiation propagating through the Kennelly-Heaviside layer (<http://tinyurl.com/25ur2t1>) - not yet discovered at that time - making possible radio transmissions: Marconi received Nobel prize for radio sender but Tesla in fact discovered the phenomenon first as was admitted after Tesla's death. Tesla also found the surface of Earth acts as a conductor with resistance roughly 10^{10} times higher than that of Copper. Tesla also discovered Schumann resonance on basis of his measurements. In my opinion the large scale effects related to di-electric breakdown discovered by Tesla are not easy to understand in the framework of Maxwell's electrodynamics and might involve new physics. It is a pity that they are seen only as an entertainment nowadays.

Cold electricity

Tesla's findings [H15, H4] (see the book by Lindeman at <http://tinyurl.com/krobpfu> and the article by Akai at

<http://tinyurl.com/yd2av3xs.html>) led him to propose the existence of "cold electricity" running as a visible current along the surface of the Tesla coil in a local direction orthogonal to the wire of the coil and consisting of charge carriers not detectable by ordinary amp-meter but generating ordinary electrons at the target.

Cold electricity was not accompanied by dissipation. For instance, the vacuum tube serving as a diode (conducting current only in single direction) was not heated by the cold currents although it generated light. In other words, the currents in question were not ohmic. This brings in mind super-conductivity not yet known at the time of Tesla's experiments. Cold electricity was thought to appear as a result of a "traffic jam" with very strong local electric field leading to a generation of high electronic surface charge densities. This suggests that a high density of electrons is necessary for the cold electricity to appear in a phase transition-like manner.

Cold electricity gave rise to a force parallel to its direction of propagation. As a child of his time Tesla identified dark electricity as aether particles. Tesla assigned to the cold electricity also scalar waves - longitudinal photons - manifesting as light emitted in dielectric breakdowns associated with air gap of primary coil and secondary coil of Tesla transmitter. Longitudinal polarization explained the force in the direction of motion of the scalar waves. Another possibility is that the momentum of cold currents transforming to that of matter gave rise to this force.

Tesla estimated the velocity of the aether particles and concluded that it was superluminal. Tesla claimed also that the energies and the voltages at the secondary coil were too large to be explained in terms of ordinary circuit theory: the discrepancy between the observed value of the voltage for bifilar coil was by a factor about 9 percent higher than predicted (<http://tinyurl.com/ybocsta5>) [H14, H13]. This might be understood if the ordinary ohmic dissipation for the cold currents was absent so that the energy of charge carriers was transformed to kinetic or electric energy as a whole. Tesla speculated with an additional energy source as an explanation of the strange energetics.

Cold electricity could be perceived as various bodily sensations for pulse lengths not much shorter than nerve pulse duration of order milliseconds. The accompanying light required very long exposure time to become visible in photos. This would suggest exotic photon-like particles were involved and had to transform to ordinary photons in order to become visible for camera. Human eye was however sensitive to this light.

What was remarkable that the time scale for the di-electric breakdown was measured in milliseconds. This happens to be the time scale of nerve pulse duration associated with the electric field of cell membrane higher than the critical value of electric field for dielectric breakdown in air. This motivates the application of TGD inspired view about quantum biology in order to understand the findings of Tesla.

10.8.2 Scalar Waves Of Tesla In TGD Framework

The scalar waves or so called non-Hertzian waves of Nikola Tesla belong to the fringe region of science. Many proponents of free energy believe that scalar waves might provide a basis for a new energy and communication technologies. Tesla himself was isolated from the official science and found no place in text books because his hypothesis about scalar waves did not fit within the framework of the Maxwell's electrodynamics. Personally I justified my personal prejudices against scalar waves by the observation that the formulations for the notion of scalar waves that I had seen seemed to be in a conflict with the cherished gauge invariance of gauge theories. The discussions with a Finnish free energy enthusiast Juha Hartikka however led me to reconsider the status of the scalar waves.

The surprise was that the non-Hertzian waves of Tesla might be possible in TGD framework. The most plausible explanation relies on many-sheeted space-time.

1. TGD allows so called massless extremals (MEs, topological light rays) as non-linear generalization of Maxwellian plane waves. They are characterized by light-like wave vector and polarization vector orthogonal to it and these vectors can also depend on space-time position [K18]. The most general wave is a pulse with arbitrary profile moving along ME with light-velocity along them and preserving its shape.

Since TGD space-time is many-sheeted one can take two waves of this kind on top of each other in the sense that their M^4 projections intersect in some region of M^4 . The effective space-time is defined by a piece of Minkowski space with effective metric which is sum of M^4 metric and deviations of the metrics of sheets from M^4 metric. Effective gauge potentials are sums of the induced gauge potentials. For two MEs the potentials at the two sheets and if the wave vectors can be chosen to be in opposite direction in which case one obtains

an effective standing wave with non-vanishing net energy but vanishing 3-momentum and classical spin. Since MEs can carry light-like charge current the resulting system carries non-vanishing charge density and vanishing current. Fourier transforms of the pair give rise to massive spinless states having identification as scalar waves possibly carrying em charge.

In TGD framework classical gauge boson fields of standard model correspond two-sheeted structures - perhaps pairs of MEs connected by wormhole contact pairs having interpretation as gauge boson. One can consider the possibility that the classical space-time correlate for gauge bosons massivation at the level of MEs is this kind of pair of spacetime sheets. For massive gauge bosons the wave vector directions of the two sheets would be opposite in the rest system and spin would be vanishing.

2. The original proposal could have been inspired by the electric-magnetic duality of TGD suggesting a large number of solutions of field equations representing constant energy density configurations of electric field assignable to bio-electrets, which would be in a well-defined sense dual to the magnetic flux tube structures with analogous properties. Also classical gravitational fields generated by classical field energy could be important in the living matter. One must however take this proposal with a big grain of salt since there is no proof for the actual existence of this kind of solutions. Furthermore, one can obtain TGD counterparts of scalar waves as pairs of MEs.

10.8.3 Relating Tesla's Work To TGD Inspired Quantum Biology

Skeptics can of course argue that if Tesla were right, his claims would have been verified long time ago. Here I disagree. Dark matter represents the deepest puzzle of modern physics, and all attempts to find dark matter identified as exotic particles of main stream quantum field theories have failed. This suggests that some assumption about the nature of dark matter is badly mistaken. Tesla's experiments tested Maxwell's electrodynamics in extreme situations - typically high voltage pulses generated in switching on of a circuit such as occur in dielectric breakdown over air gap. Interestingly, also cell membrane - another physics mystery - has a very high resting potential generating an electric field stronger than that inducing a dielectric breakdown in air. These situations are different from the extreme situations encountered in high energy elementary particle physics: long wave lengths and low frequencies are combined with high voltages, and this makes possible for the hierarchy of effective Planck constants to make itself manifest if it exist.

My TGD inspired educated guess indeed is that the hierarchy of dark matter phase labeled by the value of effective Planck constant implying macroscopic quantum coherence might have made itself manifest in the experiments of Tesla.

Cold electricity as dark matter in TGD sense

It came as a surprise to me that Tesla's findings - described in [H15, H4] - could be seen as first experimental indications for dark matter in TGD sense.

Consider first dark photons as counterparts of scalar waves of Tesla.

1. Scalar waves could correspond to dark variants of ordinary photons with a high value of effective Planck constant: later an estimate as the ratio $h_{eff}/h = ZeV/f_{AC}$ of Josephson frequency and AC frequency will be discussed. In TGD inspired biology bio-photons result in the transformation of dark photon of same energy to ordinary photon. The low intensity of bio-photons can be explained in terms of low rate for this process. This could also explain why a long exposure time was required to make the light emitted in Tesla's experiments visible. If this interpretation is correct, living matter would be an optimal detector of dark matter so that subjective experience would provide the most straightforward proof for the existence of dark matter whereas its detection by using conventional detectors would be more difficult!
2. I have earlier considered the possibility of obtaining scalar photons in TGD framework [K46], and the model of gauge bosons as pairs of fermion and anti-fermion at opposite ends of wormhole contact together with p-adic mass calculations [K78] suggests (one might even argue "predicts") the existence of longitudinal photons with very low mass. They need not

be relevant for understanding Tesla's findings if the transfer of dark matter momentum is able to explain the longitudinal force reported by Tesla.

3. Massless extremals (MEs)/topological light rays represent TGD counterparts for Maxwellian radiation fields. Their special feature is that they can carry light-like current and therefore also charge. Local polarization ϵ and light-like momentum vector k are orthogonal to each other ($\epsilon \cdot k = 0$), and the expression for the current in terms of the induced gauge field demonstrates that non-Abelian character of field makes possible charge current. In the Maxwellian case ϵ should be non-orthogonal to k . Hence charged MEs cannot correspond to Tesla's scalar waves. As in standard model, *all* particles look massless in sufficiently short length scales in TGD Universe, and all particles - including also electron - should have MEs as space-time correlates. MEs would therefore naturally correspond to dark electrons behaving like massless particles below Compton length scale of scaled up by h_{eff}/h .

In TGD framework Cooper pairs of dark electrons could thus serve as counterparts of Tesla's aether particles.

1. In TGD framework cold electricity could correspond to Cooper pairs of super-conducting dark electrons with a high value of effective Planck constant. This would explain the non-ohmic character of dark currents. If the value of h_{eff} is same for dark photons and dark electrons (this is not necessarily true), the Compton wave length of dark electrons would be by a factor E_{photon}/m_e smaller than that for dark photons. For a photon energy of 2 eV this would give a reduction factor of order 4×10^{-6} . This wave length is still macroscopic (of order of 1 m) for the needed values of $h_{eff}/h = n \sim 10^{13}$. The large value of the Compton length implies that the overlap criterion for electron wave functions is satisfied so that the formation of electronic Cooper pairs is possible and lead to a generation of supra currents which do not dissipate. The absence of ohmic dissipation could explain why the vacuum diode serving as a diode was not heated and also why energetics could not be understood in terms of ordinary circuit theory. One cannot of course exclude the possibility of remote metabolism as an additional energy source.
2. If supra currents are formed, they give rise to a path of smallest resistance so that by standard circuit theory of by hydrodynamical analogy the ohmic current along highly resistive winding of the Tesla coil is effectively replaced with the supra current flowing along its surface.
3. One must make a distinction between supra currents which can run even without any potential difference and oscillatory Josephson currents running in presence of voltage. The first guess is that the supra current runs along the surface of the coil and possible Josephson current runs between the coil and ground and is assignable to the sparks generated by the coil. The generation of supra currents and Josephson currents would be favored by the formation of very high electron densities at the locations of the coil in which the normal value of electric field was very high. Using axon as an analogy, the supra currents would flow along axon and Josephson currents between the lipid layers of the axon.

In the case of DC voltage the emerge of Josephson current with frequency determined by the DC voltage looks natural. For AC voltage the first guess is that dark Josephson current oscillating with the AC frequency (or its harmonic or sub-harmonic as will be proposed later) is established. This however requires a constant shift V_J of the Josephson voltage so that only current would remain strictly sinusoidal. V_J might explain why the observed voltage in the secondary coil of Tesla transformer is roughly 10^3 times higher than the estimated one. V_J could reflect the proposed accumulation of charge ("traffic jam") interpreted as a breakdown of the conductivity of the coil and its transformation to a capacitor carrying a constant charge. The claimed loss of the conductor property for the coil for a time interval of few milliseconds could correspond to the generation of supra current along coil and V_J between coil and ground generating Josephson current and direct Ohmic currents.

4. If super-conducting space-time sheets emerge as dark space-time sheets identifiable as n -furcations of space-time sheets at quantum criticality and if each sheet carries a Cooper pair of electrons one has the analog of Bose-Einstein condensate. One can assume that the area S

of the critical region of the surface of conductor is that of the partonic 2-surface. The guess is that at criticality the electric flux decomposes into sum of smaller electric fluxes over the sheets of n -furcation such that the small fluxes are equal to charge $2e$ of the Cooper pair.

Using $2e$ as a unit the charge the electric flux over the partonic 2-surface at criticality equals to the value of $h_{eff}/h = n$ identifiable as the total number of Cooper pairs so that one obtains an estimate for Planck constant in terms of the critical electric flux:

$$\frac{E_{cr}S}{2e} = n = \frac{h_{eff}}{h} . \quad (10.8.1)$$

This allows a pseudo-continuum of critical fluxes.

5. It would seem natural to assume “traffic jam” at some critical value of voltage between the ends of the coil implies Bose-Einstein condensate-like state of large h_{eff} Cooper pairs, Josephson currents, and supra currents. In principle this critical electric field has nothing to do with the critical field E_d for the di-electric breakdown of air. The needed phase transition would be forced by the “traffic jam” reducing the ordinary conductivity along the wire of the coil. The traffic jam would occur for some critical voltage V_{cr} between the ends of the coil.

- (a) One especially interesting value of voltage corresponds to the Compton energy of electron:

$$eV_{cr} = m_e \simeq .5 \text{ MeV} . \quad (10.8.2)$$

Also higher voltages than this were encountered in Tesla’s experiments. This condition is non-local condition. One should not confuse V_{cr} with V_J , which however can be assumed to emerge in the phase transition.

Later a justification for the condition will be considered. It is also encouraging that in Modanese-Podkletnov effect [H16] involving a capacitor for which the second plate is high T_c super conductor, radiation pulses allowing no interpretation in standard physics framework are generated above the proposed critical voltage $eV_{cr} = m_e$: the TGD inspired explanation of the effect is discussed in [K131].

- (b) Combining this condition with Eq. 10.8.1 one would have

$$E_{cr} = \frac{V_{cr}}{L} . \quad (10.8.3)$$

Here L the total length of the wire of the coil if the electric field is constant along the wire. Hence di-electric breakdowns would occur as an undesired side effect due to the very strong fields forced by the Eq. 10.8.2. In the case of cell membrane this side effect is used for neural communications using nerve pulses. Conditions of Eqs. 10.8.1, 10.8.2, and 10.8.3 would allow to fix the model to a rather high degree. Already earlier additional assumptions correlating Josephson frequency, AC frequency and the geometric characteristics of the system were considered.

- (c) In air the critical field for di-electric breakdown is $E_d \simeq 3 \text{ MeV/m}$. For higher field strengths a complete di-electric breakdown (meaning that air becomes a conductor) takes place. E_d gives for 17 cm long coil $eV \simeq m_e$ so that one can understand why dielectric breakdowns tend to occur unless coil is longer than this. Also dielectric breakdowns between subsequent turns of the coil are possible and can be seen as a nuisance. The estimate $E_{cr} = E_d$ together with the condition 10.8.1 gives for $S \in \{1 \mu\text{m}^2, 1 \text{ cm}^2, 1 \text{ m}^2\}$, $n \in \{3, 3 \times 10^8, 3 \times 10^{13}\}$. Note that the size scale of the cell nucleus defines the smallest area for which the dielectric breakdown becomes possible.

- (d) The millisecond duration of the current is same as for nerve pulse. Nerve pulse however occurs when the resting potential is reduced *below* the critical value so that the two phenomena do not obey identical physics. The current however decreases as a function of the voltage above criticality (negative resistance): does this mean that oscillating Josephson currents become dominant charge carriers above criticality and that for cell membrane this dominance is taken to extreme meaning that ohmic currents are practically absent?
- (e) One cannot completely exclude the presence of Josephson currents also below V_{cr} but due to the absence of V_J they would not contain the dominating purely sinusoidal component but would have the form

$$J_0 \sin\left(\frac{f_J}{f_{AC}} \cos(2\pi f_{AC} t)\right), \quad f_J = \frac{ZeV}{h_{eff}},$$

and periodicity defined by f_{AC} . The sine term would oscillate between values

$$\pm J_0 \sin\left(\frac{f_J}{f_{AC}}\right) = \pm J_0 \sin\left(\frac{1}{l}\right), \quad l = 1, 2, \dots$$

if the condition $f_J = f_{AC}/l$ holds true.

6. The cold currents induce electronic effects - generation of ordinary electrons - at the target. This can be understood if a phase transition to ordinary matter occurred when the criterion for the presence of the multi-furcation is not satisfied anymore. An explosion of a copper wire as it received cold electricity was reported by Tesla. This could be understood if the proposed criticality criterion was not satisfied so that the dark current was transformed to ohmic current heating the copper wire.
7. Tesla reported that dark electricity flowed with superluminal velocity and even determined this velocity. This is in principle possible in TGD Universe: sub-manifold gravity implies that the light velocity determined operationally from the time for the signal to travel between two points along light-like geodesics defined with respect to the induced metric depends on space-time sheet. In TGD inspired cosmology this light velocity is lower than the light velocity empty Minkowski space (geodesics of M^4 instead of those of space-time surface X^4). If the dark space-time sheets are nearer to M^4 than ordinary space-time sheets, the effective super-luminality follows.
8. Cold currents were not seen by amp-meter but caused subjective sensations and were visible. This conforms with TGD view about the role of dark matter in biology.

This scenario leads to concrete (almost -) predictions.

1. If amplitude modulation is the mechanism generating dark photons, the values of Planck constants involved should come as ratios of frequencies involved: only integer ratios for the frequencies can produce dark photons.
2. The energies of ordinary photons generated form a continuum such that highest frequencies correspond to frequencies assignable to photons with energy of order eV_{max} , where V_{max} is the highest voltage generated by the transmitter. Therefore the energies can be in X-ray region (keV region) and even in MeV region. The frequencies of radio waves used were in the range 20-100 kHz so that the range of values of effective Planck constants can be estimated as frequency ratio if amplitude modulation is the mechanism producing dark photons.
3. There is also the amplitude modulation of radio frequency by a frequency associated with the periodic switching of the current through the air gap caused by the di-electric breakdown. This modulation could transform the radio wave photons to dark photons with same energy but frequency considerably below kHz and these dark fields could in turn modulate the ordinary higher energy photons to dark ones so that one would obtain dark photons with frequencies below kHz and energies up to the eV_{max} .

Isn't $eV_{cr} = m_e$ condition rather ad hoc?

The first objection against the condition $eV_{cr} = m_e$ is that it looks rather ad hoc. The study of Dirac equation shows that for $V > V_{cr}$ the sign of the energy of electron changes from positive to negative so that the roles of electron and positron change. One can argue that something dramatic must happen in this kind of situation and the phase transition transforming electrons to their dark counterparts is good candidate in this respect.

An analogous situation was expected to result in atomic physics of very heavy atoms as the energy of electron changes sign in the strong electric field of heavy nucleus. It however turned out that something different takes place. In heavy ion collisions exotic pion-like states decaying to electron and gamma pairs with energy very near to $2m_e$ was observed and this led to a TGD inspired model as lepto-pions identified as bound states of colored excitations of electron [K133]. Darkness in TGD sense had to be assumed since otherwise they would be produced in the decays of weak bosons. Could something similar happen also now?

In zero energy ontology (ZEO) the natural assumption is that the scale of causal diamond (CD) is determined from the condition that the quantity $E - ZeV$ preserves its sign. This would give $m_e = eV_{cr}$ condition for the state at rest. The standard quantization condition analogous to the quantization of magnetic flux but applied to 2-surface with Minkowskian signature has the following equivalent forms:

$$\begin{aligned} \frac{ZeVT}{h_{eff}} &= n , \\ \frac{ZeV}{h_{eff}} &= nf , \quad f = \frac{1}{T} . \end{aligned} \quad (10.8.4)$$

The time interval T corresponds naturally to the time scale of CD (temporal distance between its tips). The condition for $n = 1$ is consistent implies the quantization condition proposed in previous section and motivated by the model of dark EEG:

$$\frac{ZeV}{h_{eff}} = \frac{f_{AC}}{l} . \quad (10.8.5)$$

The reason is that f_{AC} in general is harmonic of f : $f_{AC} = lf$, $l = 1, 2, \dots$. Recall that the identification of f_{AC} as cyclotron frequency for some charged boson is natural and requires that ions for which cyclotron frequencies (atomic weights in good approximation) are not multiples of each other cannot appear on the space-time sheet corresponding to same CD. One cannot however exclude the possibility that space-time sheets continue outside the CD and therefore the possibility that same space-time sheet is contained partially to sub-CD of CD.

An objection against $eV_{cr} = m_e$ condition from biology

One can invent another objection against the identification $eV_{cr} = m_e$. For cell membrane the critical membrane potential for nerve pulse generation is 0.055 eV rather than 5 MeV so that the criticality condition would not apply in this case. Does this mean that electronic super-conductivity is not possible? Should one give up the criticality condition or generalize it appropriately in this case?

The correct solution of the problem comes from the answer to the question “What happens as voltage becomes higher than the critical value V_{cr} ?”. The conjecture is that h increases to $h_{eff}/h = n$ and n -furcation replaces space-time sheet with its n -sheeted covering. But what does this mean physically?

To answer it is best to make first clear what we want and see whether we can get it.

1. We want criticality condition in the form $eV_{cr} = m_e/n$ with such an n that V_{cr} corresponds to cell membrane resting potential. Therefore mass is scaled down by $1/n$. Somehow particle splits to n fractions so that the total quantum numbers, in particular mass, remain unchanged.

2. We want p-adicity. Since p-adic length scale hypothesis allows besides standard mass corresponding to the p-adic prime $p \simeq 2^k$ characterizing the particle also mass values scaled by powers of $\sqrt{2}$, the natural guess is that p-adic length scale is increased by a factor $n = 2^{\Delta k}$.
3. We want a connection with dark matter in TGD sense: $h_{eff}/h = n$ should hold true for the resulting state. The resulting state must be interpreted as a many-sheeted structure defined by n -furcation and all quantum numbers are fractionized so that a given sheet carries q/n if total quantum number is q . A longstanding issue has been what this fractionization could mean.

By Maxwell's equations stating that potential difference is same along any path with same end points, the potential along each sheet is the same $eV_{cr,new} = M/n$. The new version of the criticality condition $eV_{cr,new} = M/n$ for single sheet of the n -fold covering is the analog of the original condition $eV_{cr} = M$ for single sheeted space-time surface. This interpretation also allows to understand the formula $E_c = h_{eff}ZeB/M$ for cyclotron energy as a formula for single sheet of covering carrying mass M/n and charge Z/n . The charge-to-mass ratio Z/M remains unchanged but summation over sheets yields the factor h_{eff}/h to the formula of E_c . Hence everything is consistent with the original motivation for dark matter hierarchy.

4. One can imagine two alternative mathematical realizations. The dark particle could correspond to a tensor product of n fractional tensor factors or to a direct sum with a complete de-localization of single fractionalized particle to various branches. For a de-localized fractional single particle state the total quantum numbers would be equal to q/n rather than the desired q whereas for tensor product of fractional single particle states the total quantum numbers are q as desired. Therefore tensor product option seems to be the correct one. The fractionized particle is analogous to a full Fermi sphere with all fractional single particle states filled.
5. One can consider also states for which any number $1 \leq m \leq n$ of single particle states are filled. $m = 1$ corresponds to the option with a complete de-localization and $m = n$ to the states proposed above. I have earlier proposed [K89] that this kind of states - I have called them N -atoms, N -molecules, etc... - might allow to understand emergence of symbolic dynamics in living matter. Fractional second quantization for n -furcations of space-time sheet seems naturally lead to these kind of states. These states allow a natural conjugation operation. A state with m sheets with each of them containing fractional particle contains holes at the remaining $n - m$ empty sheets. By replacing holes with particles and particles with holes one obtains a conjugate state. The wild proposal is that the pairing of states and their conjugates by entanglement with maximal entanglement entropy defines the molecular analog of sex. State function reduction would automatically lead to this kind of states having negentropic number theoretic entanglement and Negentropy Maximization Principle [K73] would stabilize them.

This picture is highly predictive. From the knowledge of the membrane critical potential one can calculate the value of h_{eff} and from the integer quantization of $h_{eff}/h = n$ gets constraints on the possible values of membrane potential: this constraint is unfortunately rather weak since the values of n are rather large. Situation changes if the values of n correspond to powers of 2: $n = 2^{\Delta k/2}$ so that the mass of the dark particle at given sheet of covering equals to the mass predicted by p-adic mass calculations but in p-adic scale $k_{eff} = k + \Delta k$. Note that Δk must be an even number unless one replaces the condition with the approximate condition $n \simeq 2^{\Delta k/2}$. This hypothesis might mean that the p-adic physics associated with the sheet of covering indeed corresponds to $p \simeq 2_{eff}^k$. The hypothesis predicts the p-adic prime associated with the cell membrane and also restricts strongly the value of the threshold potential of the cell membrane.

1. In the case of electron p-adic length scale hypothesis predicts the value of the threshold potential: $V_{crit}/V_{cr} = V_{crit}/m_e = n = 2^{\Delta k/2}$. For $\Delta k = 46$ one obtains $eV_{crit} = .060$ eV not too far from the nominal value .055 eV of the threshold potential. The Compton length of scaled up electron would correspond to $k = 127 + 46 = 173$, which is $20 \mu\text{m}$ - a size scale of cell - and longer than the scale $L_e(167)$. Note that the ratio $L_e(173)/L_e(151) = 2^{11}$ is approximately the same as the ratio of proton and electron masses. I have also introduced an ad hoc hypothesis that powers of 2^{11} represent preferred values of h_{eff} .

2. For biologically important ions one can find the values of membrane critical potential for which n is power of 2. Since the mass of the ion is in good approximation proportional to mass number in good approximation it is easy to get reasonable estimates for the effective (or maybe real) p-adic length scales associated with ions and for the precise value of the threshold potential. The values of k_{eff} and electrostatic energy E in threshold potential are given in Table 2 below.
3. This picture might allow to understand why nerve pulse is generated when the membrane potential is reduced *below* V_{crit} . The earlier vision about resonant interaction between dark variants of elementary particles and their p-adically scaled up versions with ordinary value of Planck constant and scaled down mass [K65] assumes that dark scaled up Compton length nL_c equals to the p-adically scaled up Compton length: this quantizes the values of $h_{eff}/h = n$ to powers of 2. In the case of electron this gives $n = 2^{\Delta k} = 2^{23}$. The reduction of the membrane potential below the critical value would transform dark electrons to ordinary electrons. Same applies to dark ions. If this is the case, the ordinary ohmic conduction would set on and lead to a generation of nerve pulse as a phenomenon analogous to di-electric breakdown. This picture could make sense also for the neutrino option. What is remarkable that ZEO and dark matter in TGD sense would be essential for understanding the highly non-intuitive fact that cell membrane system becomes unstable as membrane potential is reduced in magnitude.
4. One can try to determine the order in which different charged particles make a transition to non-superconducting phase during nerve pulse from the ordering of the values of E as $(e, p, Cl^-, K^+, Ca^{++}, Na^+)$. The inward flux of ions however begins with Na^+ ions and the outward flux with K^+ ions. That Na^+ rather than K^+ flow initiates nerve pulse is not a catastrophic prediction: the transition to a non-superconducting phase initiates the dissipative ion flow only if the concentration of non-super-conducting ions on the other side is low enough (not true in the case of K^+ in the beginning of the action potential).
5. Voltage gated ion channels are assumed for all ions. Nerve pulse can be also initiated by voltage dependent calcium channels, and in this case its duration is about 100 ms instead of few milliseconds. The TGD counterparts for the ion channels should exist and the following correspondences are suggestive.
 - Voltage gated ion channel characterized by channel protein \leftrightarrow n -furcated dark space-time sheet with n depending on ion.
 - Closed/open ion channel \leftrightarrow the magnitude of the membrane potential above/below the critical potential.

Voltage gated ion channels would correspond to dark regions of the cell membrane assignable to proteins rather than to the entire membrane as implicitly assumed hitherto. Metabolic economy (minimization of dissipation) would encourage an analogous interpretation in the case of ion pumps. Ionic pumps (<http://tinyurl.com/y7wq3w7c>) use the energy provided by ATP or the electrostatic energy $E = ZeV$ (depending on ion only via its charge) provided by the passive transfer of another ion through the cell membrane - the members of the ion pairs might be connected by a magnetic flux tube! The basic mechanism for pumps would be emission/absorption of negative/positive energy Josephson photon kicking the ion or ion Cooper pair to the other side of the membrane and thus same as in the generation of ATP. Quantal ionic pumps dissipate much less than expected, and Ling's approach postulating the absence of pumps is partially inspired by this observation.

There are also questions to be answered. The estimated value of n is same for K^+, Na^+, Ca^{++} so that one might expect them to reside at same n -sheet. Why the channel proteins are different? Do different ions correspond to different cyclotron Bose-Einstein condensates? Could cyclotron frequencies be same or related by powers of two so that local magnetic field strengths would be different and ions should correspond to disjoint parts of magnetic body.

It seems that k_{eff} could characterize genuine p-adicity that is p-adicity in the same sense as ordinary particle obeys it.

Ion	H^+	Na^+	Cl^-	K^+	Ca^{++}
$\frac{A}{Z}$	1	23	35	19	20
\tilde{E}/meV	54.6	38.0	50.0	46.0	44.0
k_{eff}	175	189	191	189	189

Table 10.2: The values of the threshold potential and effective p-adic length scales $k_{eff} = k + \Delta k$ predicted by assuming $h_{eff}/h = n = 2^{\Delta k}$. A and z denote the mass number and charge of the ion. For electron one has $k_{eff} = 173$ (prime) and $E/meV = 60$. Na^+ , Ca^{++} and K^+ all correspond to same p-adic length scale $k_{eff} = 189$ (p-adic length scale of 5 mm) if the ion is assumed to correspond to $k = 113$ for atomic nuclei. Another possibility is $k = 137$ (atomic length scale) giving $k_{eff} = 213$ (p-adic length scale of 20 meters) and should be assigned with the magnetic body.

1. I have proposed earlier that dark and possibly also p-adic copies of electroweak physics and color interactions are present in living matter for the p-adic length scales corresponding to Gaussian Mersennes $M_{G,k} = (1 + i)^k - 1$. $k = 151, 157, 163, 167$ defining four scaled up electron Compton lengths $L_e(k) = \sqrt{5}L_e(k)$ in the range $[L_e(151) = 10 \text{ nm}, \dots, L_e(167) = 2.5 \mu\text{m}]$ [K65]. Weak bosons behave as massless particles below these p-adic length scales for both p-adic and dark copies. The presence of these copies of weak physics is suggested by the large parity breaking effects in living matter (chiral selection), which are still poorly understood.
2. The hypothesis implies a large number of satellite p-adic length scales if one assumes that dark variant of particle can transform to ordinary variant of the particle characterized by a given dark scale characterized $n = 2^{\Delta k}$.
3. The recent conjecture modifies this hypothesis to a statement that given sheet of n-furcation with fractionized quantum numbers - in particular mass - obeys effective p-adic topology characterized by $k_{eff} = k + \Delta k$. In particular, the exotic weak and color physics with massless weak bosons and non-confined color below the p-adic length scale k_{eff} could be obeyed at given sheet of the covering.

Neutrino super-conductivity and cognition

The idea that neutrinos are highly relevant for cognition [K95] is rather attractive in TGD framework. One of the oldest ideas of TGD inspired biology is the notion of cognitive neutrino pair identified as pair of neutrino and antineutrino at opposite throats of wormhole contact, which I have however gave up as unrealistic. In the recent formulation this state would correspond to a superposition of photon and Z^0 boson coupling only to neutrinos. In standard model framework the idea about the relevance of neutrinos for biology is of course complete nonsense, but p-adic length scale hierarchy and TGD view about dark matter allows to consider this idea at least half-seriously. The observed large breaking of parity symmetry in living matter (chiral selection) indeed encourages to ask whether the p-adically scaled counterparts of weak gauge bosons could appear in the length scales of living matter.

There is also second wild idea. In [K24, K44] I have considered the possibility that the cell membrane can exist in two states: the first state is far from vacuum extremal and electromagnetic fields dominate whereas the second state is near to vacuum extremal and also classical Z^0 fields are important. The latter option would mean maximal sensitivity to perturbations highly desirable for cells serving as sensory receptors. This leads to a modification of the model of cell membrane resting potential and rather realistic looking estimate for the frequencies for which the retinal sensory receptors have maximum response.

1. For near to vacuum extremal option induced Kähler form is very small and in good approximation electromagnetic and Z^0 potential energies for e , ν , p and n relate to the threshold value of the electromagnetic potential energy via

$$\begin{aligned}
E(X) &= Y(X) \times eV_{crit} , \\
Y(e) &= (-1 + x) , \quad Y(\nu) = 2 - x , \quad Y(p) = 3 - x , \quad Y(n) = x , \\
x &= \frac{1}{2p} , \quad p = \sin^2(\theta_W) .
\end{aligned} \tag{10.8.6}$$

These formulas generalize to ions and allow to calculate the values of V_{crit} for near vacuum extremals from the condition $m(X) \times 2^{-\Delta k} = E(X)$, $X = e, p$ or for an ion with given value of A/z (A is mass number and z is degree of ionization). The modified threshold potential is given by $eV_{crit} \rightarrow eV_{crit}/Y(X)$ when $Y(X)$ is near unity. The expressions of $Y(X)$ are deduced in [K24].

2. The earlier model [K24] made the questionable assumption that for near to vacuum extremals the value of the Weinberg angle is $p = .0295$, which is considerably smaller than the value $p = .23$ assumed for the phase far from vacuum extremals [K24]. This assumption was motivated by the condition that the energies of biologically important ions gained in membrane potential correspond to three peak energies associated with visual receptors. It has however turned out that the ordinary value of Weinberg angle can be assumed without losing this prediction if one assumes that Cooper pairs of ions Na^+ , K^+ , and Cl^- rather than ions themselves are the charge carriers. For $p = .2397$ one obtains $(E(e), E(\nu), E(p), E(n)) = (1.085, -0.0859, 0.914, 2.086) \times V_{rest}$. Except for neutrino, the scaling factors are rather near powers of 2. Note that for proton the scaling factor is in good approximation two.
3. Dropping of two proton Cooper pairs in the production of ATP would liberate total energy of about $4 \times .055 = 0.22$ eV. The problem is that this is roughly one half of the metabolic energy quantum. If two proton Cooper pairs and two neutrino Cooper pairs are dropped, the liberated energy is of the order of the nominal value of the metabolic energy quantum. Could it be that the step producing ATP takes place in the region of cell membrane near to vacuum extremal and that also two neutrino Cooper pairs are involved in the process? Note that this discrepancy is encountered also in standard thermodynamical approach and can be overcome by assigning a gradient of chemical potential to the cell membrane. In quantum approach one cannot use this kind of argument.

If one accepts this picture, neutrino super-conductivity with neutrino Cooper pairs as carriers of Z^0 current becomes in principle possible and is even favored by energetics. I have earlier considered the possibility that neutrinos play a key role in cognition but gave up the proposed realization as unrealistic. In the recent situation one must however reconsider a new variant about the idea of cognitive neutrino Cooper pairs. A nice feature of this notion is that cognition would be shielded from electromagnetic perturbations from environment.

1. One can apply the condition $E(\nu) = m_\nu$ to see whether it is consistent with the electron and neutrino masses predicted by p-adic mass calculations in the lowest approximation [K69]. For neutrinos one can identify two options giving $m_\nu \propto \sqrt{s_\nu}$, $s_\nu = 4$ or $s_\nu = 5$. For electron one has $m_e \propto \sqrt{s_e}$, $s_e = 5$. For $s_\nu = 5$ masses are identical for same p-adic length scale. For $s_\nu = 4$ one has $m_\nu = 2/\sqrt{5}m_e = .89m_e$ in the same p-adic mass scale.
2. Assume the recent Wikipedia value $p = .23970$ for the Weinberg angle. For electron $\Delta k = 46$ giving $k = 173$ (prime) predicts $V_{eff} = 2^{-23}m_e/(-1 + x) \simeq .0561$ eV differing by 2 per cent from the nominal value .055 eV of the threshold potential for neurons.
3. For $s = 5$ neutrino $\Delta k = 54$ gives $k = 181$ (prime) and $V_{eff} = 2^{-27}m_e/(2 - x) \simeq .044$ eV differing by 10 per cent from the nominal value .040 eV of the threshold potential for photoreceptors in retina. Interestingly, one has $E(p) = eV_{eff}(p) = .040$ eV. These observations provide support for the idea that ordinary neurons/visual receptors correspond to far from/near to vacuum extremals, for the p-adic length scale hypothesis, and for the criterion $m = eV_{eff}$. Note that the p-adic mass scales for neutrinos and the light variant of electron are longer than those associated with Gaussian Mersennes. This is the case also for the ordinary weak bosons.

These considerations allow to take at least half-seriously the possibility that cell membranes correspond to near to and far from vacuum extremals depending on whether the membrane corresponds to neuron (cognition) or sensory receptor (sensory experience) and that electrons are light and dark for the far from vacuum extremals and neutrinos are light and dark for the near vacuum extremal.

Magnetic body and topological light rays from the point of view of energy storage and transfer

As noticed, in Maxwell's theory the dispersion of EM waves is problematic from the point of view of energy transmission unless geometric optics applies. In TGD Universe topological light rays possibly associated with magnetic flux tubes make possible precisely targeted communication and this difficulty might be circumvented. Remote metabolism possible in zero energy ontology also involves these structures and brings in additional flexibility.

The system using energy could store it temporarily at its magnetic body and transform the energy of cyclotron BE-condensate into various forms of energy assignable to visible matter. Tesla's vision was that energy transfer could take place in planetary scale by reflecting what he called longitudinal scalar waves from the upper boundary of Kennelly-Heaviside cavity. One can even imagine that the part of the magnetosphere associated with atmosphere, ionosphere, the part of magnetosphere rotating with Earth, or even entire magnetosphere could serve as an energy reservoir from which one could receive energy somehow. One can even ask whether solar radiation automatically takes care of the loading of these energy reservoirs. If so, the only problems to be solved would be how to control the magnetic body of the system using energy and generation of negative energy photons. One can also consider the option in which the magnetic body of the system is loaded by irradiating it with dark photons at cyclotron frequencies.

I have proposed that the generation of dark photons with given integer value of $\hbar_{eff}/\hbar = n$ is possible by performing amplitude modulation of high frequency radiation with frequency f_h using low frequency radiation such that the frequencies are related by $f_h = n \times f_{low}$. I have not been able to give a convincing justification for this proposal. This would generate dark photons with large value of $\hbar_{eff}/\hbar = n$. An open question is whether it automatically also generates dark magnetic flux tubes with accompanying the dark photons or whether they must be generated by a phase transition increasing \hbar_{eff} . In previous section a mechanism utilizing very strong electric fields and high voltages to generate dark Cooper pairs and dark photons as Josephson radiation from AC current system was discussed.

Lightnings, ball lightnings, and plasmoids as primitive life forms?

If one takes seriously the idea that Earth's electric field (see <http://tinyurl.com/y8wsggpq>) $eE_E = 100$ eV/m played the role of the electric field associated with cell membrane during the prebiotic period and also requires that the condition $eV_{cr} = .5$ MeV for the establishment of dark supra currents along helical structures, one must conclude that the minimal length of this kind of structure is about $L = 5$ km if the electric field remains constant as function of radial distance. A typical cloud-to-ground lightning flash indeed begins at this height. This would suggest that lightnings are generated when the criticality condition is satisfied.

E_E however weakens with height and the voltage associated with E_E reaches maximum $eV_E = .3$ MeV at height of 30-50 km. This is rather near to $eV_{cr} = .5$ MeV: perhaps lightning is generated when this maximum increases locally above $V_{cr} = m_e = .5$ MeV. This would mean that lightnings are initiated at much higher heights than thought and by above considerations could involve dark supra currents. This conforms with the recent observations that lightnings produce gamma rays and electrons with anomalously high energies (see <http://tinyurl.com/y8wsggpq>).

For the electric field $eE = 3$ MeV/m corresponding to di-electric breakdown in air perhaps assignable locally to the lightning the length would be $L = 18$ cm. I have proposed that plasmoids consisting of plasma and magnetic fields could correspond to primordial life forms. A charged helical structure carrying current and associated magnetic field defining its magnetic body would serve as a candidate for a plasmoid. Plasmoid and "ground" would define the "plates" of a capacitor-like system. If this view is correct, $L = 18$ cm is the minimum size scale of plasmoids (say ball lightnings).

10.8.4 How Could This Picture Relate To Biofield Research?

Various biofield therapies (healing by touch, remote healing, using electromagnetic fields, etc) rely on the observation that weak electromagnetic fields have effects on living matter and the assumption that this can be used for healing purposes. The article “Biofield Research: A Round Table Discussion of Scientific and Methodological Issues” [J17] gives an overall view about the challenges encountered. Biofield therapies represent alternative and complementary medicine and the attitudes of the mainstream are still very hostile. Bio-electromagnetism is a well-established branch of science studying effects of various kinds of electromagnetic fields on living matter and brain. Interestingly, Tesla is the father of the oldest healing method based on pulsed magnetic field generated by Tesla coil. This method is also accepted by standard medicine. The pain relieving effects of this treatment is still poorly understood. Furthermore, the work of the pioneers of bio-electromagnetism like Blackman and Adey revealed that ELF electromagnetic radiation have essentially quantal effects on brain in frequency-amplitude windows and that the field values involved are extremely small: of order 1-10 V/m in typical experiments [K44]. These effects are also poorly understood.

A further idea not accepted by mainstream medicine is the notion of “subtle energy”. The concept is often used in a metaphoric sense and it is not clear whether its meaning is nearer to that of information. A more precise meaning for subtle energy could be as some yet unknown form of metabolic energy. Note that in TGD framework metabolic energy is accompanied by negentropic entanglement and conscious information at some level of the self hierarchy.

In the round table discussion some basic theoretical problems of biofield research were summarized. What happens to the physiology of the healer during healing? What are the receptor systems and transduction mechanisms in the healee? What is transmitted between healer and healee?

TGD allows to consider a possible answer to the latter two questions [K44]. The work of Blackman and others encourages the hypothesis that the effects on vertebrate brain are quantal and correspond to cyclotron frequencies for Ca^{++} ions in magnetic field which is 2/5 of the Earth's magnetic field (.3 Gauss). For the ordinary value of Planck constant quantal effects are definitely ruled out - the energy of photons would be ridiculously small when compared with thermal energy. This could be used as a justification for the hypothesis about hierarchy of effective Planck constants $h_{eff}/h = n$ following from the basic structure of TGD, and whose applications are discussed also in this article. If the thickness of the magnetic flux tube can be controlled as one particular magnetic motor action, also the local magnetic field can be varied in certain limits, and the outcome is a narrow frequency window.

The understanding of the amplitude windows for external electric field, call it E , is more difficult and has been a longstanding challenge. This article suggests the reduction of amplitude window to a window for Josephson energy. Denote by θ the angle between the plane of plates of Josephson junction and E . The energy gained by electron as it moves the distance d between the “capacitor plates” of a Josephson junction is $eV = eEd\cos(\theta)$. It is also to the energy received by dark electron as it receives Josephson photon with energy equal to the electrostatic energy $eV = eEd\cos(\theta)$. One can argue that the momentum gained by the electron in the absorption of Josephson photon and thus also that of Josephson photon must be in good approximation tangential to the membrane layer inside which it is confined. Since the momentum of the Josephson photon is orthogonal to its polarization, $\cos(\theta)$ must be rather near to $\cos(\theta) = 1$.

1. The first proposed quantization formula proposed in this article is that Josephson frequency $f_J = ZeV/h_{eff}$ is sub-harmonic of cyclotron frequency: $f_J = f_c/l$, $l = 1, 2, \dots$, with cyclotron frequency f_c identifiable as the frequency of irradiation. This formula relates the voltage V assignable to the radiation amplitude to its frequency equal to f_c .
2. Josephson junction corresponds to a two-layered structure such that the electrostatic energy in the voltage between the outer surfaces of the structure corresponds to electron mass scaled by the value of Planck constant $h_{eff}/h = n = 2^{\Delta k}$: $eV = m_e/2^{\Delta k}$. This works nicely for cell membrane and the cautious proposal is that it works more generally.
3. A resonant interaction between “large” Josephson junctions and cell membranes is needed and becomes possible by the exchange of Josephson photons if the Josephson energies eV and the

value of h_{eff}/h - that is Δk are same for the two systems. This gives a quantization condition for the thickness of the "large" Josephson junction using the value of electric field $E = x$ V/m with x in the range $[1, 10]$: $eV = eEd\cos(\theta) = eV_{crit} = .055$ eV giving $d\cos(\theta) = 5.5/x$ cm. $x = 1$ corresponds to $\cos(\theta) = 1$ giving that the thickness of the Josephson junction is 5.5 cm: this is roughly the scale of brain hemisphere. Variation of the angle θ gives frequency window via $\cos(\theta) = 1/x$. At least two frequency windows are reported and correspond to $x \in [1/2, 1]$ and $x \in [1/10, 1]$. Already in the first case the range for θ would be 60 degrees. It seems that several values of d in the range of $[.55, 5.5]$ cm are required in both cases. They could correspond to p-adic length scales $L_e(k)$ in the range $k \in [181, 183]$ for the first case and $k \in [177, 183]$ for the latter case.

4. Cell membrane as Josephson junction is only a macroscopic description of the situation. Membrane proteins defining channels and pumps are very natural candidates for a more precise microscopic description of Josephson junctions at cell membrane scale. Ca^{++} channels would be especially interesting in this respect since Ca^{++} is a boson and can form Bose-Einstein condensates as such. The natural question is what are the microscopic counterparts of Josephson junctions in longer length scales.

What would be transmitted between the healer and healee could be dark photons and possibly also dark electrons and even ions. The ability to generate negentropy would be also transmitted and perhaps a better manner to think about the situation is to regard healer and healee as a single system as long as the flux tube connections generated by reconnection of flux tubes are present. Also remote metabolism in which healee emits negative energy Josephson photons received by healer can be considered.

10.8.5 Tesla Coils From TGD View Point

In the sequel coils considered by Tesla are reconsidered from TGD viewpoint and an attempt to understand in more detail the phase transition to dark matter as a phenomenon accompanying resonance is made.

Is the model for the resting potential really consistent with the interpretation of Tesla's experiments?

Is the proposed picture consistent with what happens in Tesla's experiments, where very high voltages somewhat above $eV_{crit} = m_e$ were created? In living matter the voltage values are much lower and this determines the value of $n = 2^{\Delta k/2}$. Does this mean that one has $n = 1$ in Tesla's experiments? This would be rather disappointing but could quite well make sense for the coil-Earth system regarded as capacitor. In both situations very strong electric fields are encountered and the idea about large value of n is very attractive.

The solution ansatz assumes generation of light fractional electrons as in the case of cell membrane and starts from the idea that the subsequent turns of Tesla coil are analogous to the lipid layers of cell membrane and define Josephson junctions. The observed radiation assigned to dark currents could also correspond to Josephson radiation.

1. Since electric voltage propagates with finite velocity of order light velocity along the coil, there is a potential difference between corresponding points of two subsequent turns of the coil. Could it be that super-conductivity sets on and oscillatory Josephson currents flow between the two subsequent turns and the observed light emission can be assigned with dark currents is Josephson radiation? The electric field is very strong at points where charge accumulates and one expects phase transition. Since the maximal value of the oscillating potential difference between subsequent turns above critical voltage $eV_{cr} = m_e$ is smaller than eV_{cr} , a scaling of electron mass downwards is however expected to occur by the proposed criterion for cell membrane: $m_e \rightarrow m_e/n$, $n \simeq 2^{\Delta k/2}$, $n = h_{eff}/h$. Electrons would become light.
2. To estimate n one can use a simple estimate for the voltage as function of time and angle variable ϕ along the helical coil of radius R given by equations $z = KR\phi$, $\rho = R$. The distance along coil given by $s = \sqrt{1 + K^2}R\phi$. One can express K as the ratio of height to

the total length s_{tot} of the coil: $K = h/s_{tot}$. The voltage is given by $V(t, \phi) = V_0 \sin[\omega_{AC}(t - \sqrt{1 + K^2 R \phi/c})]$. The voltage difference between points of subsequent turns with values of ϕ differing by 2π is $\Delta V \simeq (\partial V/\partial \phi)2\pi = (\partial V/\partial t)2\pi R\sqrt{1 + K^2/c}$. Josephson current is given by

$$J = J_0 \sin\left(\frac{\int dt \Delta V}{h_{eff}}\right) = J_0 \sin\left[\frac{2\pi}{f_0} \frac{1}{h_{eff}} V(t)\right] , \quad f_0 = \frac{c}{R\sqrt{1+K^2}} . \quad (10.8.7)$$

3. Near zeros of V one has in the first approximation $V(t) = V_0 \omega(t - t_{max})$ and Josephson current behaves as

$$J_0 \sin[\omega_{eff,J}(t - t_{max})] , \quad (10.8.8)$$

where

$$\omega_{eff,J} = (2\pi)^2 \frac{f_{AC}}{f_0} V_0 \frac{1}{h_{eff}} \quad (10.8.9)$$

defines the analog of Josephson frequency for effective voltage

$$V_{eff} = (2\pi)^2 \frac{f_{AC}}{f_0} V_0 . \quad (10.8.10)$$

If one applies the earlier argument this would mean that the critical voltage $eV_{cr} = m_e$ is scaled down to $V_{eff,cr} = (2\pi)^2 \frac{f_{AC}}{f_0} m_e$ and that electron becomes dark electron with p-adically scaled down fractional mass at each sheet of multi-furcation.

4. Using the proposed formulas $h_{eff}/h = n = 2^{\Delta k/2} = V_{cr}/V_{eff,cr}$ one obtains the estimate $n = (2\pi)^{-2} \frac{f_0}{f_{AC}}$. For $R = .1$ m and f_{AC} in the range $[20, 10^2]$ kHz one would have n in the range $[380, 76]$. The condition $n = 2^{\Delta k/2}$ restricts the range to even powers of 2: $\Delta k = \{16, 14, 12\}$. The corresponding p-adic scales would be $L_e(k)$, $k = 127 + \Delta k$ giving $k = 143, 141, 139$. $k = 139$ corresponds to atomic length scale and $k = 143$ to $4 \times L_e(139)$.
5. The surface density of electronic charge carriers should be few electrons per surface area defined by $L_e(k)$. This condition looks reasonable since electron density is about one electron per atomic volume. On the other hand, from the critical value of electric field in air the charge density would be only few electron charges per μm^2 (cell size scale). Electrons should indeed separate to its own dark phase at n -sheet. This would also lead to high charge density for ions inducing dielectric breakdown.

What traffic jam in Tesla coil could mean?

What “traffic jam” or its analog could mean from the circuit theory point of view and how the traffic jam could be resolved in TGD framework?

1. First trial

In the following a simple manner to illustrate the idea in terms of effective description of coil as L, C, and R in series is discussed first.

1. It is essential that in the experiments of Tesla both primary and secondary coils were in resonance with the same resonance frequency so that primary coil acted as driving force for the secondary and in the resonance created the situation possibly forcing the new physics to emerge via a phase transition to dark matter phase. Primary feeds the secondary with a sinusoidal input at resonance frequency. Modelling the secondary as a circuit with L , C , and R in series, one obtains simple second order differential equation for its behavior

$$\frac{Ld^2I}{dt^2} + R\frac{dI}{dt} + \frac{I}{C} = \frac{dV_{ext}}{dt} \equiv g(t) = A\sin(\omega_0 t) \quad (10.8.11)$$

The right hand side represents the voltage assignable to the primary. For L , C , R in parallel one must express effective R , C , L using the real R , C and L using the formula for $1/Z$ as sum of $1/R, 1/C, 1/L$. Resonance frequency transforms however from $1/\sqrt{LC}$ to $\sqrt{R/L}$ in parallel case at the limit of vanishing R . $R = 0$ in complete resonance for series is replaced with $R = \infty$ for parallel case (the current does not flow at all through R so that the outcome is pure L, C circuit).

2. Solutions are sums of two solutions of homogenous equation and a special solution of inhomogenous equation. Solutions of the homogenous equation reduce to linear combinations of two exponent functions

$$I_{\pm}(t) = \exp(-\Omega_{\pm}t) \quad , \quad \Omega = \frac{-R}{2L} \pm i\omega \quad , \quad \omega = \sqrt{\frac{1}{LC} - \left(\frac{R}{L}\right)^2} \quad . \quad (10.8.12)$$

3. The solutions of inhomogenous equation can be obtained by the variation of coefficients for homogenous solutions that is in the form $I_{\pm}^s = C_{\pm}(t)I_{\pm}(t)$ and are given by

$$I_{\pm}^s(t) = \int_0^t \frac{g(t)}{L} I_{\pm}(t) dt \times I_{\mp}(t) \quad . \quad (10.8.13)$$

The outcome from the exponentials is a combination of trigonometric functions and constant functions, which vanish at origin. The resonance corresponds to $\omega = \omega_0$ and means that the exponential decay for the special solutions is compensated by the energy feed. At the limit $R/L \rightarrow 0$ the amplitude of I_{\pm} divergences and the solution for R/L is combination of trigonometric functions multiplied by t so that the envelope of the solution increases linearly.

4. Physically the resonance means that the charge of the capacitor oscillates with amplitude, which becomes very large at resonance $\omega = \omega_0$ (the amplitude is proportional to L/R at resonance for the series case): note that large inductance makes the resonance stronger. The charge of the coil begins to fluctuate with a large amplitude. To estimate the charge notice that in a reasonable approximation the current has same phase along the coil. The reason is that the voltage represents a signal propagating with almost light velocity along the coil and the phase change $\Delta\phi = \omega T = \omega L/c \sim 10^{-3}$ and therefore rather small. Charge is given by $Q(t) = \int I(t)dt$ in good approximation (current all points of coil is in the same phase).
5. Near resonance the amplitude of charge oscillations becomes very large and the system must become unstable. Something must happen. TGD inspired proposal is a transition containing plasma phase and dark matter and dark magnetic flux tubes as a counterpart of Tesla's cold currents.

Second trial

Second trial is inspired by catastrophe theory.

1. Voltage and frequency would be the control variables and $|Z|$ could be taken as behavior variable if cusp is assumed to model the situation. There would exist a critical frequency interval inside which two phases are possible. The first phase could be ordinary and second phase could correspond to di-electric breakdown generating plasma and dark currents flowing along dark magnetic flux tubes. This is just one possibility but perhaps the most realistic one. The transition to the phase containing plasma and dark currents takes place at certain frequency above certain critical voltage and frequency range becomes wider as the voltage increases. Plasma can be assigned with the capacitor defined by the di-electric surrounding the coil and the super conducting dark phase with the dark magnetic body of the coil itself. Both are generated at say “the lower” sheet of the cusp. The critical voltage corresponds locally to surface charge density (essentially normal component of electric field at the surface of the conductor) above which di-electric breakdown takes place.
2. The end points of the frequency interval correspond to effective resonances since a sudden transition between the two phases takes place as one approaches the apparent resonance frequency either from below or above. For genuine resonance would result from both sides and hysteresis is basic prediction of this model. L, C, R change in discontinuous manner inducing discontinuous change of Z . In particular, the phase changes suddenly and discontinuously so that resonance interpretation is suggestive but would be wrong. Catastrophe theory with $|Z|$ as behavior variable predicts discontinuity of $|Z|$ at the transition.
3. The phases have electric *resp.* magnetic character, and would be in certain sense duals of each other. In second phase dissipation is small and therefore also $|Z|$ is small whereas in the second phase dissipation is larger and $|Z|$ is large. Whether resistance increases or decreases in the transition to dark plus plasma phase depends on the proportion of the two phases involved.
4. In this picture one does not have genuine resonances but pairs of dual phase transitions. Unfortunately, the testing of this proposal is not easy since the impedances are measured assuming linearity and using rather weak voltages around 1 V whereas plasma phase and cold currents are generated at voltages, which are above kilovolt scale. Intriguingly, the resonances appear in this kind of situation as pairs, and it is possible to reproduce them by a suitable circuit model. It does not look too plausible that small amount of dark phase and plasma could be present at so low voltages but one must have an open mind in this respect.
5. It is possible to obtain also a connection to real resonances since in the vicinity of the resonance frequency the criterion for the formation of plasma is expected to be satisfied for high enough voltage. If the value of surface charge density is what matters then the frequency dependent real part of the charge of the coil defined as integral of the current $I = V/Z$ near resonance determines the threshold for the generation of the plasma and dark current. The total charge per area of the coil must be above certain critical value corresponding to the critical electric field at which di-electric breakdown occurs. This threshold condition defines the boundaries of the region of (V_0, ω) plane inside which the two phases can be present. The phase transition between ordinary and plasma containing phases takes place at its boundaries. Cusp catastrophe would correspond to a frequency interval around resonance.

Could one detect the generation of dark matter in the behavior of frequency dependent impedance?

The generation of dark matter would involve also the emergence “dark magnetic flux tubes”. Dark magnetic flux tube would correspond topologically to the analog of n -sheeted covering space for $n = h_{eff}/h$. Ohmic currents would be replaced with dark supra currents flowing along dark magnetic flux tubes and correspond to Tesla’s cold electricity. The generation of strong electron densities and thus strong electric fields at the surfaces of the conductors - in particular coils - is the prerequisite for the phase transition to dark electronic super-conductivity. This would manifest itself as local dielectric breakdowns as in the experiments of Tesla. Resonances mean strong ohmic currents and the phase transition could accompany resonances for sufficiently high voltages.

If the dark magnetic fields correspond to separate space-time sheets carrying dark electron Cooper pairs, there is a temptation to conclude that the presence of the dark currents (“cold

electricity" of Tesla) is not seen in the description of circuits using ordinary circuit theory applying only for the visible matter. In particular, one can argue that the contribution of the induced dark magnetic fields to the inductance characterizing visible matter becomes vanishing. In the framework of circuit theory this would look like a transition to a state in which the visible part of system - say coil - behaves like a capacitor. Here one must make distinction between two meanings of capacitance: could behave like a charge reservoirs defining together with ground a capacitor like system or could itself becomes analogous to a pair of capacitor plates. If the second end of the system is grounded, these two views seem to be more or less equivalent.

1. In circuit theory description this kind of transition would be analogous to a resonance since it involves a change of the sign of the phase of the frequency dependent impedance $Z(\omega)$ when the reactance $X(\omega)$ in the expression of impedance

$$Z = R + iX, \quad X = \omega L - \frac{1}{\omega C}$$

vanishes. Note that system is modelled as R, C , and L in series. R, C , and L are assumed to be slowly varying functions of frequency ω and provide effective reparameterization for the frequency response of a complex system.

Also modelling as R, C , and L as parallel is possible and means that inverse of Z is sum of inverses of various contributions. This means a reparameterization giving:

$$\omega_{\pm} = -i\frac{1}{2RC} \pm \frac{1}{2}\sqrt{-(\frac{1}{RC})^2 + \frac{4}{LC}}.$$

One can say that these resonances are duals of each other and related by $R/L \leftrightarrow 1/RC$. One can say that the roles of inductance and capacitance are changed in the parallel coupling. Note that at the limit $R \rightarrow 0$ in parallel case second resonance frequency approaches to $\omega_{+} = \sqrt{\frac{R}{L}}$. Note that the limit of very large R gives $\omega_{\pm} = \pm 1/\sqrt{LC}$. The interpretation is that the current does not flow through R and one obtains pure L, C resonance.

2. The resonances of course have interpretation in terms of ordinary circuit theory thinking and possible phase transitions to dark phase only accompany the resonances. The turns of the coil are insulated from each other and same applies to the primary and secondary of a transformer like system as well as components of a system consisting of several coils. The insulation is obtained by using di-electric which polarizes so that one obtains effectively capacitor like systems since insulating material develops a polarization as a reaction to the charge of the coil. One has effectively L and C in parallel. This gives rise to a resonance frequency. Since C behaves like surface area per distance between the plates, and L is proportional to the length of the coil, the resonance frequency decreases with the size of the coil.

Resonance interpretation in strong sense requires also that the values of the phase are near to $\pi/2$ for the inductive phase and $-\pi/2$ for the capacitive phase for R, C, L in series. For R, C, L in parallel the roles of L and C are changed. The strength of the resonance depends on how large the change of the magnitude of the phase angle of Z is. One has two kinds of resonances depending on the sign of the change of the phase angle as ω increases. For R, C, and L in series the transition from capacitive to inductive phase - Φ decreases - would correspond to series resonance in ordinary circuit theory, where capacitance dominates at low frequencies for series configurations. Increase of Φ could be called "antiresonance". Parallel resonance would correspond to the increase of Φ as function of ω and decrease for "antiresonance". In the following I will speak only about resonances. The resonance with a phase transition decreasing/increasing Φ is expected to be followed by a reverse transition increasing/decreasing it in the case that Φ is near $\pm\pi/2$ between resonances (this requires small enough real part of Z).

3. For coils these two kinds of resonances are expected to correspond to different kinds of phase transitions.

- (a) An obvious and directly observable phase transition occurring at resonance is the generation of plasma phase in di-electric breakdown from the surface of di-electric surrounding coil wire or from the di-electric surrounding entire coil. This phase transition dissipates energy, and one expects that resistance increases in the vicinity of the resonance as function of ω . This means also maximum for reactance. Phase transition like property would suggest sharp peak like maximum instead of a smooth parabolic maximum.
 - (b) The phase transition to dark super-conductivity is expected to be assignable to the coil itself and involve generation of dark magnetic flux tubes and Cooper pairs of dark electrons as current carriers at it. This phase transition is expected to reduce dissipation and induce a peak like minimum in resistance difficult to explain in terms of plasma generation - this assuming that impedance corresponds to the entire current rather than only its visible part. This is the case if the dark current transforms to ordinary one in the measurement of the current-voltage frequency response.
 - (c) These two phase transitions have electric *resp.* magnetic character and are could be seen as duals. The data about impedances of certain kind of coils suggests that these phase transitions occur pairwise at nearby frequencies ω_1 and ω_2 spanning a frequency range $[\omega_1, \omega_2]$ inside which the sign of the phase angle Φ between current and voltage remains constant. Even Φ is expected to be approximately constant for small enough values of resistance. The could be also seen as support for the proposal that resistance has maximum/minimum, which could be assigned with the proposed two kinds of phase transitions.
 - (d) There is however a strong objection against this speculative line of thought. Complex circuitry can produce this kind of behaviors without any new physics. This is clear from the rules for the analytic expressions of the circuit parameters as one builds circuit from smaller circuits in parallel or in series. The phase transitions related to new physics should occur for strong electric fields above the threshold for dielectric breakdown. The peaky behavior however occur also for the impedances obtained using low input voltages (actually the only possible manner to determine impedance) so that poor resolution is the natural explanation for it.
4. Since the dark matter resonance could induce (quantum) phase transition and criticality, one expects that various physical observables are in general non-analytic functions of the dimensionless parameter $(\omega - \omega_0)/\omega_0$ near ω_0 . This applies also to the phase transition to plasma phase. ω would be analogous to temperature and ω_0 to a critical temperature. Whereas high temperature super conductivity is in finite temperature range, the dark phase would exist in the recent situation in finite frequency range around the resonance frequency (of course, also the temperature range could be finite).
 5. Typically non-analytic sharp peaks involving functions u^m , where one has $u = |(\omega - \omega_0)/\omega_0|$ and m is so called critical exponent, appear. For $|Z|$ one expects have $m < 1$ meaning divergent and discontinuous derivative at ω_0 . The sides of the curved "V" (possibly upside down) would be convex - in other words, the derivative would decrease in magnitude as one proceeds from the singularity outwards. Ordinary circuit theory predicts a smooth parabolic behavior $|Z| = \sqrt{R^2 + bu^2}$ for which "V" would be replaced with what looks like a bottom of a smooth potential well. For very small resistance R this situation looks in a non-optimal frequency resolution like $Z \simeq R + ku$ having discontinuous but *finite* derivative at ω_0 . These are very general qualitative predictions and easily testable using sufficiently high frequency resolution so that the local diffeo-invariants can be identified reliably.
 6. It could quite well be that the resonances look like smooth parabolic peaks in good enough frequency resolution. This does not mean that the assignment of phase transition to the resonance is physically wrong. In TGD framework the notion of resolution is an essential part of the physical description and different length scale resolutions correspond to different sheets of many-sheeted space-time. At small space-time sheets the description in terms as

ordinary resonances could quite well make sense. Of course, already the usual description of critical systems relies on the notion of resolution - in the recent case for frequency and the successes of the conformal field theory justify fully the notion of resolution.

TGD based view about high T_c superconductors provides additional insights about the situation.

1. Since charge carriers are concentrated at the surfaces of conductors, conductors are effectively 2-D systems and since quantum TGD itself describes a universe which is effectively 2-dimensional, 2-D conformal field theories with temperature replaced with frequency as an external parameter could provide a lot of theoretical information about the system both at criticality and in its vicinity. Of course, dark phase could also occur in finite temperature range as the properties of living matter suggest. One should of course test whether linearity is true or whether also amplitude of the oscillating voltage could a parameter analogous to the dimensionless parameter $(\omega - \omega_i)/\omega_i$ so that dark phase would exist also in voltage windows.

By conformal invariance the observables are scaling covariant at criticality and various correlations functions behave in a simple manner at criticality being characterized by anomalous dimensions. In the vicinity of critical point various observables are simple power functions of $(\omega - \omega_i)/\omega_i$ characterized by critical exponents (<http://tinyurl.com/ybk13c8c>). The anomalous dimensions and critical exponents do not depend on the details of the system, and one characterizes the system by its universality class near criticality.

2. In TGD inspired model of high T_c superconductivity the analog of percolation (say (liquid trickling through a porous material) (<http://tinyurl.com/34nujm>) serves as a basic mechanism of high T_c superconductivity. Magnetic flux tubes with relatively small value of h_{eff} would be present and super-conducting but have short length. In the phase transition to super-conductivity the flux tubes would be scaled up in length and combine to longer ones corresponding to larger value of h_{eff} and supra currents would flow through the entire wire. In 2-D case the phase transition to percolation is believed to be describable by a 2-D conformal field theory.

There exist rather detailed theoretical results about the behavior of the system at criticality and outside it and it might be possible to extrapolate these results to the recent case. One should be however very cautious since in TGD framework the view about renormalization group evolution crucial for the standard view about criticality is not quite the standard one.

3. Continuous coupling constant evolution having continuous scaling parameter as argument is in TGD framework replaced with a discrete evolution with discrete hierarchy of p-adic length scales replacing continuous scale. All physical states corresponds to fixed points of renormalization group for each p-adic length scale. 2-D conformal field theories indeed describe fixed points renormalization group which the effective 2-dimensionality of TGD Universe implied by strong form of holography and general coordinate invariance conforms with this. Various quantum criticalities differ only in the degree of criticality measured by the number of variables which are critical. In catastrophe theory the singularities of potential function provide a visualization of the situation: the simplest situation occurs with potential has extremum. A more critical situation occurs when also the matrix defined by the second derivatives of the potential function has vanishing determinant. This sequence can be continued indefinitely if the numbers of control parameters and behaviour variables are arbitrarily large.

What does this general picture imply in the recent situation? For instance, should one interpret the entire frequency range in which system is dark super-conductor as critical so that the standard thermodynamical picture assigning criticality only to the phase transition point would not apply as such in quantal situation. It seems that self-organized criticality is nearer to the TGD picture although the critical system is not attractor in the ordinary sense in TGD framework. State function reduction generates critical states and negentropic entanglement and Negentropy Maximization Principle guarantees their stability.

What would be remarkable is that the generation of dark matter phase would be directly measurable using standard measurements. For instance, one could study the frequency dependence

of impedance for simple coils and transformers to see whether resonance involving minimum of frequency dependent resistance occur and whether they look like phase transitions - being peaked. If this is the case, one could study the properties of the system around resonance and try to identify further signatures for dark matter (say Josephson currents between turns of a coil). The conclusion is that it is better to be very cautious: the exotic phenomena are expected to occur for very high voltages and electric fields for which linear circuit theory fails. Peaking however occurs for weak voltages so that they are probably due to poor resolution.

Could the arrow of time change in electric circuits?

The change of the arrow of geometric time means that dissipation as a loss of energy takes place in reversed time direction. Second law holds still but in a generalized form. In zero energy ontology (ZEO) the quantum jump sequence corresponds to a sequence of pairs of state function reductions to the opposite boundaries of causal diamonds (CDs) defined as intersections of future and past directed light-cones. The arrow of geometric time would change in each state function reduction since the state is prepared state at either boundary and de-localisation occurs at opposite boundary whose position (and thus the size of CD in quantum superposition) varies.

For large enough CDs the arrow of geometric time as perceived by an observer would remain constant. For short time scales characterizing CD the observer would interpret the change of the arrow of time as thermodynamical fluctuations. In living matter the change of the geometric arrow of time might take place continually. Italian theoretician Fantappie indeed suggested long time ago that this might be the case and introduced the notion of syntropy. Syntropy could be interpreted in TGD framework as time reversed counterpart of entropy [J92].

The reversal of the arrow of geometric time implies that the system becomes apparently an over unity system producing energy instead of dissipating it. Since dissipation power equals to $P = I^2/R$ in circuit theory, time reversal would imply a negative resistance. The concrete signature for the change of the arrow of time is that the magnitude of the phase angle between the current and voltage defined by the impedance would become larger than $\pi/2$.

There are indications for this kind of phenomenon in coil like systems. For instance, the measurements of inductance for a coil reported in the master thesis "Voltage distribution along reactor winding under very fast transients" by Salman Ejaz and Saeed Anwar (<http://tinyurl.com/ydx85jwa.pdf>) demonstrate this kind of effect (Figure 9) [H6]. The graphs of impedance demonstrates also the change of the sign of the phase angle as function of frequency suggesting interpretation as a time reversed resonance. The radical interpretation would be as a temporary change of the arrow of geometric time. Also over-unity effects have been reported - in particular by the free energy community.

The transition to time reversed situation occurs by state function reduction suggesting that it cannot be performed continuously. For a given CD one cannot change the arrow of time in a continuous manner by going through an intermediate frequency for which resistance vanishes. This conclusion does not hold true if the system decomposes a collection of CDs with different arrows of geometric time in the transition.

Skeptic can invent at least the following objections against this interpretation.

1. The system measuring the impedance does not work properly and gives phase whose magnitude exceeds $\pi/2$ predicted by the positivity of resistance.
2. The model of an electric component using LCR parameterization is only an effective description for a complex system which can involve also a generation of plasma phase meaning that the coil is not anymore a closed system since charge carriers leak out. It can happen that the magnitude of the phase difference between current and voltage can become larger than $\pi/2$.

Could remote metabolism work for a Tesla coil acting as a capacitor?

The best manner to demonstrate new phenomenon is to generate it artificially. The previous considerations suggest a possible model for how artificial remote metabolism could be realized in terms of something akin to Tesla coil or magnifying transmitter. Bifilar coil (<http://tinyurl.com/mvweora>) looks like a promising realization of the coil. There are two options corresponding to the possibilities that the currents in the two components of bifilar coil runs in same or opposite

directions. In the latter case, the magnetic field generated by the bifilar coil is very weak and coil acts as capacitor.

1. The secondary in Tesla transmitter acts as both inductance and capacitor. The alternating magnetic field associated with the inductance implies magnetic motor activity for topologically quantized magnetic field, and would make it ideal for developing reconnections with the flux tubes of a larger magnetic body providing via remote metabolism the energy and charge to the secondary acting as a capacitor. It is however essential that the strength of the magnetic field at the flux tube is same as that at the larger magnetic body.
2. The model for cold electricity in terms of dark matter suggests that when the voltage along bifilar coil exceeds critical voltage V_{cr} , it becomes charged and together with Earth forms a capacitor in voltage V_J defining Josephson potential for the resulting Josephson junction. A good guess for V_{cr} is $eV_{cr} = m_e = .5$ MeV. V_J is rather high and above the critical voltage V_d for dielectric breakdown. The generation of charge is due to the "traffic jam" for electrons making also possible the phase transition to dark matter. If this picture is correct, Josephson currents do not appear below V_{cr} and coil or bifilar coil acting as a capacitor is necessary for the remote metabolism. The constant part of voltage would make the resulting coil/capacitor hybrid analogous to cell membrane. Also DNA double strand could serve as a similar coil/capacitor-like system: now the traffic jam would correspond to the presence of two electron charges per nucleotide due to the attached phosphates expected to relate closely to metabolism and therefore also remote metabolism.
3. For general coils or bifilars for which the currents are parallel the transition to the dark phase would have measurable circuit theoretic correlates. The traffic jam for electrons would generate dark supra phase propagating along dark magnetic flux tubes. Only very weak ordinary magnetic fields are generated. Therefore the inductance in visible sector is very small and system becomes capacitive. The resonance like transitions from a situation in which the phase of the frequency dependent impedance $Z = R + i(\omega L - 1/(\omega C))$ (R, L and C depend on ω) characterizing physics in the visible sector suddenly changes sign and changes from almost $\pi/2$ to $-\pi/2$ could be seen as a measurable signature for the generation of dark Cooper pairs (cold currents of Tesla). Dark phases could appear in finite frequency ranges.
4. The interpretation in terms of the credit card mechanism would suggest that the resulting system is able to store energy at its magnetic body and also load it when needed - even from foreign magnetic body. The loading should be a spontaneous process and understandable in terms of the need to survive reducing to Negentropy Maximization Principle [K73]. Hence the system would in this respect act like a living system. Loading means the sending of negative energy signals to the magnetic body as phase conjugate Josephson photons. This involves also the change of the arrow of the embedding space geometric time in the time scale defined by single cycle of the process. Macroscopic quantum phenomenon would therefore be in question.

10.8.6 Tesla's Findings From A New Viewpoint

Tesla's experiments with induction coils generated strong AC electric fields inducing charge separations leading to di-electric breakdowns through the surrounding air, kind of mini-lightnings. I have proposed that both real and mini-lightnings involve large h_{eff} phase making possible high temperature super-conductivity along pairs of magnetic flux tubes forming possible U-shaped loops which reconnect with the target: this provides a model for high T_c superconductivity. There is evidence that electrons in lightnings travel to the surface of Earth with very low dissipation and also gamma rays are observed. These facts are not consistent with the standard physics models for lightnings since the dissipation in atmosphere does not allow these phenomena.

A concrete model for the Cooper pairs would be as pairs of electrons at neighboring tubes with magnetic fluxes which have same (opposite) directions. The presence of magnetic fields concentrated at flux tubes favors formation of $S = 1, L = 1$ Cooper pairs ($S = 0, L = 2$) Cooper pairs [K23, K108, K94].

To proceed one should try to find a more concrete model for the generation of large value of h_{eff} making possible super-conductivity.

How to understand the value of h_{eff} ?

The basis problem is to understand how h_{eff} depends on the parameters characterizing the situation at the magnetic flux tube connecting two systems. I have considered several mechanisms for the generation of large h_{eff} phase.

1. The model for h_{eff} in systems involving charge separation stimulated by AC current was based on the identification of Josephson frequency with the frequency of AC current: $f_J = E_J/h_{eff} = f_{AC}$ predicting $h_{eff}/h = E_J/hf_{AC}$ [K9].

The findings of Pollack and the difficulties to understand metabolic energy quantum of nominal value 5 eV in the simplest model for cell membrane as Josephson junction as Josephson energy for Cooper pair equal to $ZeV = 10-10.6$ mV inspired the assumption that cyclotron energies at flux tubes traversing cell membrane can be different at the two sides of the cell membrane [K44, K94]. This would lead to a generalization of the notion of Josephson junction associated with the transmembrane protein and generalizes $f_J = f_{AC}$ to $\Delta f_c + f_J = f_{AC}$ predicting $h_{eff}/h = E_J/(h(\Delta f_c - f_{AC}))$ so that h_{eff}/h would get arbitrarily large values near resonance $f_{AC} = f_C$. Note that correct sign requires $\Delta f_C - f_{AC} > 0$.

2. The conjecture $\hbar_{eff} = \hbar_{gr} = GMm/v_0$ could make sense at microscopic level for particle-Earth pair and would predict a universal spectrum of bio-photons if identified as resulting from the decays of dark cyclotron photons to bio-photons. The first guess for the parameter v_0 would be as a rotational velocity associated with the two systems such as Earth and electron rotating with it. In case of planetary orbits $v = v_0$ is not consistent with

$$\frac{v}{c} = \frac{\sqrt{\frac{v_0}{c}}}{4\pi n}$$

following from Bohr rules in $1/r$ potential (n denotes the principal quantum number).

3. $h_{eff} = h_{em} = Z_1 Z_2 e^2 / v_0$ hypothesis is a natural looking generalization in systems involve large charge separations, say the exclusion zones discovered by Pollack providing a model for prebiotic life forms. The philosophy would be that when the coupling strength between systems becomes so large that perturbation theory fails, the value of h_{eff} increases and makes perturbation theory in powers of $1/h_{eff}$ possible again. At space-time level this means emergence of non-determinism so that 3-surfaces at the future and past boundaries of causal diamond are connected by n-branched space-time surface for which branches fuse at the two ends. Dark matter would be Nature's manner to define what non-perturbative phases are. The strong hypothesis $h_{eff} = h_{em} = h_{gr}$ might make possible reconnection between em and gravimagnetic flux tubes and ATP synthase is here a candidate system.
4. Rotating magnetic systems with high negative charge are also good candidates for generating large h_{eff} at the magnetic flux tubes possibly contain dark proton sequences identifiable as dark nuclei. I have also proposed that a system subject to constant torque allowing description in terms of potential function which is multivalued as function of the angle coordinate ϕ leads rather naturally to generation of large h_{eff} [K63] when one requires internal consistency.

Could dark electrons or protons at magnetic flux tubes serve as current carriers?

There are clearly many options for h_{eff} to choose if one wants to model Tesla's findings. Some options are characterized by AC frequency and some options by rotation velocity. The electrons in the secondary Tesla coil were believed to get stuck which one could take to mean that ohmic AC current does not flow anymore. If this really occurs electrons do not carry any current and high negative local charge density is generated.

One can consider several mechanisms for the super-conductivity.

1. Some fraction of electrons flows as dark Cooper pairs along magnetic flux tubes. The members of the Cooper pair could reside at the flux tubes of the approximately dipolar magnetic field located in the interior of the coil and at the exterior of the coil near its surface and carrying magnetic fluxes in opposite direction. The interaction of spin with magnetic field usually

tends to disrupt the Cooper pair but not it stabilizes it. One can consider several guesses for the value of h_{eff} since AC current is in question.

2. If the notion of exclusion zone makes sense also for more general systems than water, one might guess that perhaps dark magnetic flux tubes carrying dark protonic currents along them are generated. The objection is that water is not present now and this option works only if there is source of protons. This option does not look very promising now.

Second challenge is to identify candidates for the supra currents and Josephson currents possibly appearing in the system.

1. Mini-lightnings carrying supra currents could form when U-shaped flux tubes from the secondary coil reconnect with “ground” and dark supra current flows along them. The formula $h_{eff} = Z_1 Z_2 e^2 / v_0$ or even $h_{gr} = M_{EM}(pair) / v_0$, v_0 rotational velocity of Earth, suggests itself now. Z_2 could be the charge $2e$ of the Cooper pair and Z_1 could be assigned with ground as charge reservoir.
2. One can also consider Josephson currents flowing along flux tube pairs associated with the time-dependent dipole magnetic field accompanying the coil. They would replace the Ohmic AC currents when electrons are “stuck”. Josephson frequency would coincide with AC frequency.

In the case of Josephson current the problem seems to be that the voltage defining Josephson frequency varies periodically as also the magnetic field for AC current. The sticking of Ohmic charge is however expected to destroy AC current so that one would obtain static voltage if ohmic DC current runs through the coil. Thus DC current seems to be necessary.

Static magnetic fields are also necessary for high T_c super-conductivity. They are achieved if the AC component of the Ohmic current becomes small or vanishing. In Maxwell’s ED also a small DC current present unless the coil contains ferromagnet. In TGD Universe it is also possible that a magnetic field with flux tubes carrying monopole flux requiring no DC current is generated. This kind of monopole magnetic fields could be responsible for the magnetic fields encountered in cosmology and astrophysics (the observed fields are 11 orders of magnitude stronger than the predicted) and could also appear in superconductors and even in ferromagnets.

In this situation the formula $h_{eff}/h = E_J/hf_{AC}$ would state that the coil acts as a generalized Josephson junction with AC current replaced with Josephson current with $f_J = E_J/h_{eff} = f_{AC}$. The formula $h_{eff}/h = E_J/(h(\Delta f_c - f_{AC}))$ would require that the magnetic field strengths at the ends of coil are different so that also the cyclotron frequencies are different. AC frequency would be equal to the generalized Josephson frequency: $f_{AC} = \Delta f_c - E_J/h_{eff}$. In this case one can consider even the possibility that there is no DC current so that one has $f_{AC} = \Delta f_c$. This fixes the increment ΔB for the magnetic field.

10.9 Teslaphoresis in TGD

I found an interesting popular article about a recently discovered phenomenon christened Teslaphoresis [D16] (see <http://tinyurl.com/htyaf4h>). This phenomenon might involve new physics. Tesla studied systems critical against di-electric breakdown and observed strange electrical discharges occurring in very long length scales. Colleagues decided that these phenomena have mere entertainment value and are “understood” in Maxwellian electrodynamics. The amateurs have however continued the experiments of Tesla, and Teslaphoresis could be the final proof that something genuinely new is involved.

In TGD framework these long ranged strange phenomena could correspond in TGD quantum criticality and to large values of Planck constant implying quantum coherence in long length scales. The phases of ordinary matter with non-standard value $h_{eff} = n \times h$ of Planck constant would correspond to dark matter in TGD framework. I have earlier considered Tesla’s findings from TGD point of view and my personal opinion has been that Tesla might have been the first experimenter to detect dark matter in TGD sense. Teslaphoresis gives further support for this proposal.

The title of the popular article is “Reconfigured Tesla coil aligns, electrifies materials from a distance” tells about the effects involved. The research group is led by Paul Churukuri and there is

also an abstract about the work in ADS Nano journal [D16] (see <http://tinyurl.com/z3qybx2>). This article contains also an excellent illustration allowing to understand both the Tesla coil and the magnetic and electric fields involved. The abstract of the paper provides a summary about the results.

This paper introduces Teslaphoresis, the directed motion and self-assembly of matter by a Tesla coil, and studies this electrokinetic phenomenon using single-walled carbon nanotubes (CNTs). Conventional directed self-assembly of matter using electric fields has been restricted to small scale structures, but with Teslaphoresis, we exceed this limitation by using the Tesla coil's antenna to create a gradient high-voltage force field that projects into free space. CNTs placed within the Teslaphoretic (TEP) field polarize and self-assemble into wires that span from the nanoscale to the macroscale, the longest thus far being 15 cm. We show that the TEP field not only directs the self-assembly of long nanotube wires at remote distances (≥ 30 cm) but can also wirelessly power nanotube-based LED circuits. Furthermore, individualized CNTs self-organize to form long parallel arrays with high fidelity alignment to the TEP field. Thus, Teslaphoresis is effective for directed self-assembly from the bottom-up to the macroscale.

To sum up: what is found that single-walled carbon nanotubes (CNTs) polarise and self-assemble along the electric fields created by capacitor in much longer length scales than expected. Biological applications (involving linear molecules like microtubules) come in mind. CNTs tend to also move towards the capacitance of the secondary coil of the Tesla coil (TC).

In the sequel the TGD counterparts for the Maxwellian em fields involved with Tesla coils are considered in TGD framework and it is found that many-sheetedness of space-time is necessary to understand the standing waves also involved. The fact that massless extremals (MEs) can carry light-like currents is essential for modelling currents classically using many-sheeted space-time. The presence of magnetic monopole flux tubes distinguishing TGD from Maxwellian theory is suggestive and could explain why Teslaphoresis occurs in so long length scales and why it induces self-organization phenomena for CNTs. The situation can be seen as a special case of more general situation encountered in TGD based model of living matter.

10.9.1 What Tesla coils are?

Wikipedia contains a nice description of Tesla coils (<http://tinyurl.com/mh68y7b>). Also the abstract (see <http://tinyurl.com/z3qybx2>) provides an illustration about the Tesla coil used.

Harmonic oscillator serves as an indispensable mechanical analogy for time dependent voltage source $V(t)$ and components (L, C, R) coupled in series to form a closed circuit. The dynamics is governed by differential equation

$$L \frac{d^2 I}{dt^2} + R \frac{dI}{dt} + \frac{I}{C} = dV_{ext}(t) . \quad (10.9.1)$$

Here L inductance (associated with coils in the illustration) with LdI/dt telling the voltage between ends of the inductance coil, C is the capacitance associated with the metal torus telling the charge of the capacitor ($Q = CV$) in potential V relative to the ground. Also relative capacitance with ground replaced with metal object in constant potential and V with the voltage between the two makes sense. IR is the contribution to the voltage of the circuit. V_{ext} is the external voltage. The mechanical analogy corresponds to $(I, L, C, R, dV_{ext}/dt) \leftrightarrow (x, m, 1/k, K, F_{ext})$ where (x, m, k, K, F_{ext}) are the position, mass force constant, friction, and external force applied on the harmonic oscillator.

The circuit consists of three parts (see <http://tinyurl.com/hetyaac>).

1. The first part has in parallel inductance L_0 and AC source characterized by voltage amplitude V_0 and frequency f acting as external driving force. L_0 corresponds to the outer coil in the figure of abstract.
2. The primary circuit has inductance $L_{1,1}$ and capacitance C_1 in series in the situation in which di-electric breakdown has not taken place so that the current switch defined by the air gap is off. There is also internal resistance R_1 , not included to the illustration. In the simplest model for the situation the voltage U_1 relates to U_0 by $U_1/U_0 = N_2/N_1$, where N_2 and N_1

are in numbers of windings for the two coils. On the other hand, one has $U_1 = Q_1/C_1$ equal to $(N_2/N_1)U_1$.

When the value of the electric field associated with U_1 exceeds critical value (in the range 5-30 kV/m) dielectric breakdown takes place and the current starts to run in the entire primary circuit $(L_{1,2}, R_1, C_1)$ and induces via the coil $L_{1,2}$ a current in secondary circuit (L_2, R_2, C_2) . $L_{1,1}$ corresponds in the illustration of the article to a tunable inductance and L_2 corresponds to the inner cylindrical coil. C_2 corresponds to the sum of the stray capacitance of L_2 and capacitance C_2 of the metal torus.

The circuits $(L_{1,1}, L_{1,2}, R_1, C_1)$ and (L_2, R_2, C_2) are chosen so that their resonance frequencies are the same and equal to the input frequency to achieve resonance. The frequencies are in radio frequency range and according to Wikipedia article vary in the range 50 kHz to 1 MHz. The duration of the on-period much longer than the corresponding time scales.

What happens during the on-period is that capacitor C_2 develops oscillating charge and oscillating electric field orthogonal to the capacitor at its surface. Also oscillating magnetic field is induced: here the possible current along the electric field lines affects the situation. Also at this dielectric breakdowns can occur if the local electric field near the C_2 exceeds critical value.

The discovery is that the radial oscillating electric fields induces what is christened as Teslaphoresis (for more general phenomenon of dielectrophoresis see <http://tinyurl.com/hgj645q>). What is seen as surprising is that the phenomenon takes place in length scales longer than 30 cm. The wavelengths of the AC photons vary in the range [124 m , 6 km]. The fact that Tesla managed to produce this kind of strange phenomena in a length scale of entire town suggests that the wavelength of the radio waves is the key scale, perhaps quantum scale.

CNTs polarize and self-organize along the field lines of the electric field involved. CNTs can also self organize to form a wiring between LEDs and extract energy from the fields of TC so that the LEDs shine. This would be a partial fulfilment of Tesla's dream about wireless energy transfer. If the length scale involved is that of radio waves, the dream might be realized in rather long scales. Also the tractor effect is observed: CNTs are attracted towards TC along electric field lines. This can be understood if they develop polarization parallel to the electric field of the capacitor C_2 .

10.9.2 How TGD could be involved?

My earlier attempts to understand what happened in Tesla's circuits [K46, K9] inspired the question whether some new physics could be involved. The presence of effects in unexpectedly long length scales raises the question whether quantum criticality and the hierarchy of Planck constants could be involved. The conjecture has indeed been that quantum criticality leads to a generation of phases of ordinary matter with non-standard value $\hbar_{eff} = n \times \hbar$ of Planck constant and thus quantum coherence in length scales scaled up by factor n from what they are usually [K36, K37, K38, K39]. Dielectric breakdown is a critical phenomenon and an essential part of the functioning of TC. The test for the hypothesis is to look whether the effects disappear when the coupling between primary and secondary is not by dielectric breakdown.

Radio wavelengths are used. The experience from quantum biological models [?] encourages to ask whether the photons become dark at quantum criticality and whether their energies $E = \hbar_{eff} \times f$ are above thermal energy. TGD inspired quantum biology would suggest that the energies could be in visible and UV range just as bio-photons identified as decay products of dark photons. Large energy of dark radiowave photons would make possible effective energy transfer along long distances. The transformation of dark photons to ordinary photons would generate energetic photons and could serve as a signature of the effect analogous to bio-photons. The self-organization of CNTs along electric field line should involve macroscopic quantum coherence.

The modelling of time varying electromagnetic fields involves open questions in TGD framework. Consider first the available building bricks [K18, K11].

1. The embedding of any em field locally is possible but the imbeddability to CP_2 implies topological field quantization, which is reasonably well understood for static fields. The preferred extremal property reflecting strong form of holography implying effective 2-dimensionality

poses further powerful constraints at the level of single space-time sheet so that extremely restricted repertoire of field patterns is expected to be possible.

At the level of many-sheeted space-time the situation is different. The Maxwellian limit of TGD is obtained by replacing the sheets of many-sheeted space-time with single region of Minkowski space and by summing induced gauge potentials at various sheets (test particle experiences touching space-time sheets experiences the sum of gauge potentials and induced gravitational field identified as sum CP_2 parts of the induced metric).

2. There are excellent reasons to assume that cosmic string solutions $X^2 \times Y^2$ with X^2 minimal surface in M^4 and Y^2 a homologically non-trivial complex surface of CP_2 allow deformations to magnetic flux tubes having 4-D CP_2 projection. One can make Lorentz boosts for the magnetic flux tubes and together with many-sheetedness this makes possible complex repertoire of moving quasi-stationary fields patterns at Maxwellian limit.
3. Deformations of CP_2 type vacuum extremals provide description of Euclidian space-time regions identified as lines of generalized Feynman diagrams. The light-like 3-D boundaries between Minkowskian and Euclidian space-time regions having degenerate 4-metric can equivalently regarded as lines of generalized Feynman diagrams are identified as orbits of 2-D partons performing kind of zitterbewegung with local light-velocity. The average velocity is typically time-like.
4. Massless extremals (MEs) are radiation type solutions but with local directions of polarization and light-like local propagation 4-velocity $(1, v(x))$ with $1 - v \cdot v = 0$. Since the direction can vary the average current is typically time-like.

The first special feature is that MEs allow light-like currents parallel to $(1, v(x))$. Second special feature is that linear superposition is restricted to four-momenta proportional to the local four-velocity $(1, v(x))$ so that one can say that all Fourier components correspond to parallel four vectors $((1, v)$ and $(-1, -v)$ are regarded as parallel). Field pulses propagate in single direction without change in shape and in precisely targeted manner, which is optimal situation concerning information transfer.

The general linear superposition of Maxwell's theory is lost and one can say that for given space-time sheet the field decomposes to quanta in geometric sense. Linear superposition is however replaced with set theoretic union of parallel space-time sheets: the test particle experiences the sum of gauge potentials associated with different sheets so that nothing is lost in Maxwellian limit.

Consider now what the TGD description could look like for standing waves.

1. Only linearly polarized waves with local wave vector k are possible. Circular polarizations are not representable classically. In many-sheeted space-time the problem can be solved by using two parallel space-time sheets with of orthogonal linear polarizations and suitable phase lag.
2. In circuit systems there are oscillating electric fields associated with the capacitor and also oscillating magnetic fields and electric fields accompanying them. These fields do not propagate although one can assign to them frequency and wave vectors locally. In Maxwellian theory they can be represented as superposition of real waves propagating in opposite directions with light-velocity $(\cos(\omega t - kx) + \cos(\omega t + kx) = 2\cos(\omega t)\cos(kx)$, $\omega = k$ using unit $c = 1$).

In TGD framework standing wave solutions are not possible as radiative solutions since only the waves with parallel local 4-velocities can superpose. At least two parallel space-time sheets representing copies of MEs related by 4-D reflection are needed to describe the fields in the region outside capacitor. Since the electric field is radial at the surface of capacitor C_2 , the MEs should propagate parallel to C_2 near its surface.

Maxwell's theory involves currents in an essential manner although their description involves structural equations and is therefore only phenomenological. These fields have 4-currents as sources. In the recent case the currents are associated with the surfaces of inductances and more or less stationary charge densities with the surfaces of the capacitors.

1. In TGD framework the 4-currents correspond at quantum level to fundamental fermions at string world sheets and together with partonic 2-surfaces string world sheets carry the data needed by the strong form of holography (SH). This microscopic description is quite too far from the practical modelling of Tesla coils. SH guarantees 4-D description and the question concerns the translation of 2-D vocabulary to 4-D one. One question is what the fermionic currents assignable to the ends of fermionic strings correspond in 4-D vocabulary.
2. The field equations for Kähler action do not contain external currents explicitly. MEs however allow light-like currents parallel to them and by using parallel MEs with light-like currents boosted in opposite directions it is possible to obtain time-like net currents at Maxwellian limit.

In particular, one can have stationary charge densities needed at the surfaces of C_2 as well as currents moving with non-relativistic velocities needed at the surfaces of the induction coils. The rule could be that parallel MEs gives rise to net current parallel to microscopic fermionic currents propagating along partonic surfaces: these currents can look stationary in induced metric at partonic 2-surfaces so that it need not expand).

3. String world sheets have their ends carrying fermion number at the 3-D light-like orbits of partonic 2-surfaces. Since monopole fluxes connect wormhole throats, the strings are parallel to monopole flux tubes connect fermions moving along light-like curves of space-time surface. If indeed so, magnetic flux tubes and ME form locally orthogonal network. One cannot therefore neglect the magnetic flux tubes (carrying dark matter). In the recent case this would suggest the presence of dark magnetic flux tubes in directions orthogonal to the capacitor C_2 . These flux tubes would carry monopole flux and no current would be needed to generate this magnetic field: the cross section would be two sheeted closed surface rather than disk with boundary.

The monopole magnetic flux tubes carrying dark matter emanating radially from capacitor C_2 would be essential for new physics effects. In particular, dark supra currents could flow along these flux tubes. Together with MEs they are proposed to play fundamental role in TGD inspired quantum biology.

To sum up, the TGD inspired model of Teslaphoresis could be seen as an application of basic ideas of TGD inspired quantum biology explaining macroscopic quantum coherence and dark matter. If so, Tesla would have observed dark matter and new quantum theory based on the hierarchy of Planck constants already century ago.

Chapter 11

TGD View about Water Memory and the Notion of Morphogenetic Field

11.1 Introduction

This article was inspired by the proposal of Savelev *et al* published since 2019 that there exists what they call DNA resonance code [?, ?, ?]. (see <https://cutt.ly/KAe6B0d>, <https://cutt.ly/rArqd1A>, and <https://cutt.ly/EArqzSL>).

11.1.1 Motivations for the introduction of morphogenetic field

Morphogenesis is one of the very poorly understood problems of biology. The mystery is how the genes can encode for the shape of the organism and guide the morphogenesis. It is extremely difficult to understand the coherence of living organisms in terms of mere biochemistry alone and the basic mechanisms of bio-catalysis are still poorly understood. Even taking into account electromagnetic fields, it is very difficult to understand how stochastic dynamics, which seems unavoidable in the standard physics, could explain morphogenesis.

This has motivated the introduction of the notion of morphogenetic field. Support for its existence and hints about its nature come from several unexplained findings made already by Gurwitch. Belousov, Burkalov and many others continued the work of Gurwitch [I77] and produced evidence for the existence of the morphogenetic field.

Water memory is a strange phenomenon, which still induces highly emotional responses in the mainstream community although the basic objection has long ago become obsolete: if water forms representations of molecules the extreme dilution produces no problems. Benveniste and Montagnier [I103] involving the basic procedure used to produce homeopathic remedies have produced evidence that the morphogenetic field is electromagnetic and generated by DNA and interacting with it: the low frequency spectrum of the bio-active molecules can be even recorded and it creates same biological effects as the real substance. The experiments also produce support for water memory and the basic method of homeopathy involving repeated dilutions and agitation plays a central role in the experiments. Montagnier has also produced evidence for the remote replication of DNA.

Also Peter Gariaev belongs to the pioneers and phantom DNA could have interpretation as a morphogenetic field: Gariaev talks about wave DNA [I82, I85, I128, I83]. I have written with Peter Gariaev an article about remote replication of DNA [K149].

Fröhlich condensates [J76, I119, I135] [J76] are analogous morphogenetic fields and would be generated by electric dipoles. They would explain the coherence of biosystems, which is very difficult to understand in the standard physics framework. No direct support for these fields has been found hitherto.

Miller and Webb [I160] proposed 2012 that the morphogenetic field is holographic and would be generated by DNA.

The authors of the articles [?, ?, ?] that motivated this work, propose that morphogenetic field could be generated by DNA and might realize genetic code electromagnetically making it possible to transform the genetic information in terms of shape and form of the organism in morphogenesis.

11.1.2 The counterpart of morphogenetic field in the TGD framework

Quantum TGD brings in new physics elements crucial for TGD inspired quantum biology. The idea about p-adic physics as a description of correlates of cognition emerged around 1993. The systematic work with quantum biology and consciousness started around 1995 when I made also the first p-adic mass calculations. The first publication "Biological systems as quantum coherent systems" related to quantum biology appeared in CASYS2000 conference proceedings in 2020. During the first years of millenniums several ideas emerged, mention only the hierarchy of Planck constants as a possible explanation of dark matter, its number theoretical interpretation, and the notion of $M^8 - H$ duality.

This led gradually to what I call adelic physics. Adelic physics includes not only real numbers but also p-adic number fields and their extensions and was published 2017 [L55, L56] in a book by Springer. The notion of p-adic physics was originally inspired by the p-adic mass calculations and by the idea that p-adic number fields provide the correct language for the description of cognition. The requirement of number theoretical universality led to the realization that the hierarchy formed by extensions of rationals defines an evolutionary hierarchy behind the biological and other evolutionary hierarchies.

The articles published in the Journal of Non-locality and Remote Mental Interactions (2002-) and in Journal of Non-locality (2012-), both founded by Lian Sidoroff, give an idea about the evolution of TGD and TGD inspired quantum biology and consciousness theory. The articles published in journals founded by Huping Hu (2010-) give a view about the detailed evolution of ideas since 2010. In this article, as in all my articles and books about TGD, the references to TGD are to the updated versions of articles and books at my homepage.

Besides general problems, which might be regarded as philosophical, the anomalies of the physicalistic world view have served as the source of inspiration. Several poorly understood phenomena have played a central role in the "Poirot-like" process leading to the development of TGD based views about quantum biology. Mention only the effects of ELF em fields on vertebrate brain [J31], biophotons [I166, I108], water memory [?, I102, I104], Pollack effect [I126, I125, L25, ?, ?], and Comorosan effect [?, I65]. The notion of syntropy by Fantappie [J92], which challenges the belief that the arrow of time is not always the same in living systems, has been also inspiring. Also the work of Rupert Sheldrake relating to morphic resonance [?, ?] has been inspiring.

In this article I will discuss the TGD based vision and the above listed phenomena, which are often forgotten. I have written during years several articles about morphogenesis from TGD point of view [L23, L40, L73, L46, L14] and I will compare the TGD based view with the proposed interpretation of morphogenetic field as em field generated by DNA and realizing genetic code discussed in the articles of Savelev *et al* [?, ?, ?], and compare it with the TGD based models of genetic code realized in terms of dark nucleons and dark photons. The findings described in these articles and in the articles of Yolene Thomas [?, ?] about water memory also provide new tests for the TGD based view. As always, this kind of process led to some new ideas and insights.

11.2 Basic ideas of TGD

In this section I will describe briefly the basic ideas of TGD relevant to quantum biology, cognition and consciousness.

11.2.1 TGD view about space-time

1. The background comes from the new physics predicted by Topological GeometroDynamics (TGD). TGD emerged as a proposal for the unification of fundamental interactions [K2] and was based on the proposal that space-times are representable as 4-D surfaces in the 8-D space

$H = M^4 \times CP_2$, the product of Minkowski space and complex projective space CP_2 . TGD can be also regarded as a generalization of string models obtained by replacing 1-D strings in 10-D space with 3-surfaces in H and identifying the orbit of 3-surface as a space-time region.

2. The new view of space-time and 3-space brings the shape of 3-surface as a new degree of freedom. This also implies new topological degrees of freedom not possible in general relativity, where the condition that space-time is a small deformation of M^4 does not allow them. Even Euclidean signature of the induced metric is possible and realized for the space-time surfaces representing elementary particles. Geometrization of classical fields of standard model and quantum numbers emerges. The notion of field body (magnetic body) is of key importance in TGD inspired quantum biology.
3. Holography is one of the key notions of TGD and also central in the TGD based model of living matter. Holography in the sense that 3-D data determine the space-time surface as a preferred extremal analogous to Bohr orbit follows from general coordinate invariance in the TGD framework [K60, K102] [L116].

One aspect of holography is the hologram like character of the space-time surface. Space-time as a conscious hologram is indeed the basic idea of TGD inspired theory of consciousness [K20]. Space-time sheets of the many-sheeted space-time located inside causal diamonds (CDs) form a hierarchy defining cognitive representations with a varying degree of accuracy and abstraction level. In the TGD framework, this translates to the p-adic length scale hierarchy and $h_{eff} = nh_0$ hierarchy of phases of ordinary matter behaving like dark matter and follows as a prediction of adelic physics [L55, L56].

11.2.2 Number theoretical vision

The concrete realization of adelic physics involves $M^8 - H$ duality as a basic building brick. $M^8 - H$ duality [L90, L91, L95] realizes evolutionary hierarchy number theoretically, justifies the hierarchy of dark matter as $h_{eff} = nh_0$ phases of ordinary matter, provides a detailed understanding of p-adic length scale hypothesis, and predicts Galois confinement as a universal mechanism for the formation of bound states. All these notions are central in the TGD inspired quantum biology.

$M^8 - H$ duality

One of the key discoveries was $M^8 - H$ duality, which states that geometrization of physics has as dual its number-theoretization.

1. The details of M^8H duality have developed slowly during years via several side tracks. In this view, space-times correspond to both 4-surfaces in H and in the complexification of M^8 . At the level of M^8 they correspond to "roots" of polynomials P of real argument having rational coefficients and continued to polynomials with octonionic argument. Associativity as is the dynamical principle determining the 4-surfaces in M^8 and requires associative (quaternionic) normal space.
2. It took a long time to realize, or rather to admit, that the "roots" correspond to 3-D mass shells of $M^4 \subset M^8$ rather than 4-surfaces as the naive expectation was. 4-D surfaced X^4 in M^8 are defined by holography, which provides an alternative explicit definition of $M^8 - H$ duality, which associates with $X^4 \subset M^8$ a 4-D space-time surface in H . The image of X^4 is a minimal surface [L121] H with singularities, which is analogous to soap film with frames. The space-time surface in H is a preferred extremal analogous to Bohr orbit, which means that, apart from singularities, it is a simultaneous extremal of both volume action and so called Kähler action analogous to Maxwell action. This picture has a twistorial generalization and implies the twistor lift of TGD.
3. M^8 is analog of momentum space so that $M^8 - H$ duality, which maps the 4-surface in M^8 to space-time surfaces in H , can be seen as a generalization of momentum position duality of wave mechanics motivated by the replaced of point-like particles with 3-D surfaces. Cognitive representations as points of X^4 for which the momentum components are algebraic integers

define a unique discretization of X^4 . In the generic case their number is finite. At the mass shells $H^3 \subset M^4$ corresponding to the roots of P defining 3-D cross sections of X^4 the cognitive representation explode and can contain momenta with components which are algebraic integers and even rationals. One can say that intelligence as algebraic complexity is concentrated at 3-D mass shells and their images in H under $M^8 - H$ duality. This also explains why the world is experienced as 3-D.

4. Polynomial P with rational coefficients defines an extension of rationals partially characterized by its Galois group and by ramified primes appearing as divisors of the discriminant of the polynomial. The largest ramified prime is identified as the p-adic prime assignable to the space-time region. This notion emerged already around 1995 via p-adic mass calculations and the recent view gives justification for the p-adic thermodynamics and generalizes it to the level of scattering amplitudes. The functional composition of polynomials is an attractive general way to build many-particle states at the level of M^8 and leads to very detailed proposal for the transition matrix [L122, L123]. It is also analogous to composition of functions, which plays a key role in computationalism. Nature would be a computationalist in a number-theoretically universal sense.
5. Number theoretical universality requires that the momenta of fundamental particles (actually quarks) as points of mass shells in $M^4 \subset M^8$ are algebraic integers. Periodic boundary conditions however imply Galois confinement as an analog of quark confinement. The conditions require that the physical states are Galois singlets: in particular, the momentum components are ordinary integers in the scale defined by the p-adic prime. This gives a universal mechanism for the formation of bound states [L114, L116].

Dark matter as $h_{eff} = nh_0$ phases

Number theoretical vision provides a justification for several key notions of TGD based quantum biology and introduced before the recent understanding of $M^8 - H$ duality [L90, L91, L116, L122, L123].

1. Number theoretical vision leads to an identification of dark matter as phases of ordinary matter with Planck constant $h_{eff} = nh_0$, where n is the dimension of extension of rationals defined by P . h_{eff} can be much larger than h . This proposal emerged considerably earlier (around 2007) and was motivated by the strange effects of ELF radiation on the behavior and physiology of vertebrates [J31].
2. h_{eff} hierarchy makes quantum coherence possible in arbitrarily long scales and magnetic bodies (MBs) of the systems would carry dark matter in this sense. MB has an onion-like structure with layers labelled by h_{eff} and layers would form a master-slave hierarchy with ordinary biomatter at the bottom.
3. The value of h_{eff} depends on the character of interactions mediated by the flux tube. $h_{eff}/h < 100$ could be associated with valence bonds and hydrogen bonds [L51] and more generally to flux tubes mediating electromagnetic interactions.

Nottale hypothesis [E2] introduces gravitational Planck constant $\hbar_{gr} = GMm/v_0$, where $v_0 < c$ has dimensions of velocity. In the TGD framework \hbar_{gr} is interpreted as a genuine Planck constant and reflects dark matter, which corresponds to a high-dimensional extension of rationals [K111, K85]. Note that the dimension of extension can be exponentially larger than the degree of the polynomial P : if the Galois group is the permutation group for roots, the dimension is $n!$.

The large value of \hbar_{gr} conforms with the long range of gravitational interactions and predicts quantum gravity in arbitrarily long scales. The gravitational Compton length $\Lambda_{gr} = GM/v_0$ for a particle with mass m is independent of m and of the order of the Schwarzschild radius for mass M . Also cyclotron energy $E_c = \hbar_{gr}ZeB/m = GMZeB$ is independent of m . Both these features conform with the Equivalence Principle and are expected to play a crucial role in quantum biology [K88] [L62, L118].

Could the TGD view of space-time allow us to understand genetic holography?

A living organism consists of cells that are almost identical and contain DNA that is the same for all of them but expresses itself in different ways. This genetic holography is a fundamental property of living organisms. Where does it originate? Dark DNA associated with magnetic flux tubes is one of the basic predictions of the TGD inspired biology. One can say that the magnetic body controls the ordinary biomatter and dictates its development. Could one have a structure that would consist of a huge number of almost identical copies of dark DNA forming a quantum coherent unit inducing the coherence of ordinary biomatter? Could this structure induce the self-organization of the ordinary DNA and the cell containing it.

Could one understand this by using the TGD based spacetime concept. There are two cases to be considered. The general option is that f_i are analytic functions of 3 complex coordinates and 1 hypercomplex (light-like) coordinate of H and $(f_1, f_2) = (0, 0)$ defines the space-time surface.

A simpler option is that f_i are polynomials P_i with rational or even algebraic coefficients. Evolution as an increase of number theoretic complexity [L56] suggest that polynomials with rational coefficients emerged first in the evolution.

- (a) For the general option (f_1, f_2) , the extension of rationals could emerge as follows. Assume 2-D singularity X_i^2 (partonic 2-surface) at a particular light-like partonic orbit (m_i such orbits for f_i) defining X_i^2 as a particular root of f_i . If f_2 (f_1) is restricted to X_1^2 *resp.* X_2^2 , and is a polynomial P_i^2 with algebraic coefficients, it has m_2 *resp.* m_1 discrete roots, which are in an algebraic extension of rationals with dimension m_2 *resp.* m_1 .

Note that m_2 can depend on X_i^2 for the general option. Only a single extension appears for a given root and can depend on it. The identification of $h_{eff} = n_i h_0$ looks natural and would mean that h_{eff} is a local property characterizing a particular interaction vertex. Note that it is possible that the coefficients of the resulting polynomial are algebraic numbers.

For the polynomial option $(f_1, f_2) = (P_1, P_2)$, the argument is essentially the same except that now the number of roots of P_1 *resp.* P_2 does not depend on X_2^2 *resp.* X_1^2 . The dimension n_1 *resp.* n_2 of the extension however depends on X_2^2 *resp.* X_1^2 since the coefficients of P_1 *resp.* P_2 depend on it.

- (b) The proposal of the number theoretic vision of TGD is that the effective Planck constant is given by $h_{eff} = n h_0$, $h_0 < h$ is the minimal value of h_{eff} and n corresponds to the dimension n_E of the algebraic extension of rationals. As noticed, $n = n_E$ would depend on the roots considered and in principle $m_1 m_2$ values are possible. This identification looks natural since n_E defines the dimension of the extension. $n = m_1 m_2$ can be also considered for the polynomial option but looks artificial. For the general option, the degree of the polynomial P_1 can depend on a particular root X_2^2 of f_2 .
- (c) The dimension n_E of the extension depends on the polynomial and typically seems to increase with an exponential rate with the degree of the polynomials. If the Galois group is the permutation group S_m it has $m!$ elements. If it is a cyclic group Z_m , it has m elements.

For the original view of M^8-H duality, single polynomial P of complex variable with rational coefficients determined the boundary data of associative holography [L90, L91, L154]. The iteration of P was proposed as an evolutionary process leading to chaos [L94] and led to an exponential increase of the degree of the iterated polynomial as powers mk of the degree m of P and to a similar increases of the dimension of its algebraic extension.

This might generalize to the recent situation [L163] if the iteration of polynomials P_1 *resp.* P_2 at the partonic 2-surface X_2^2 *resp.* X_1^2 defining holographic data makes sense and therefore induces a similar evolutionary process by holography. This could give rise to a

transition to chaos at X_i^2 making itself manifest as the exponential increase in the number of roots and degree of extension of rationals and h_{eff} .

One can consider the situation also from a more restricted point of view provided by the structure of H .

- (a) The space-time surface in $H = M^4 \times CP_2$ can be many-sheeted in the sense that CP_2 coordinates are m_1 -valued functions of M^4 coordinates. Already this means deviation from the standard quantum field theories. This generates a m_1 -sheeted quantum coherent structure not encountered in QFTs. Anyons could be the basic example in condensed matter physics [K89]. m_1 is not very large in this case since CP_2 has extremely small size (about 10^4 Planck lengths) and one would expect that the number of sheets cannot be too large.
- (b) M^4 and CP_2 can change the roles: M^4 coordinates define the fields and CP_2 takes the role of the space-time. M^4 coordinates could be m_2 valued functions of CP_2 coordinates: this would give a quantum coherent system acting as a unit consisting of a *very* large number m_2 of *almost* identical copies at different positions in M^4 . The reason is that there is a lot of room in M^4 . These regions could correspond to monopole flux tubes forming a bundle and also to almost identical basic units.

If m_i corresponds to the degree of a polynomial, quite high degrees are required. The iteration of polynomials would mean an exponential increase in powers d^k of the degree d of the iterated polynomial P and a transition to chaos. For a polynomial of degree $d = 2$ one would obtain a hierarchy $m = 2^k$.

- (c) Lattice like systems would be a basic candidate for this kind of system with repeating units. The lattice could be also realized at the level of the field body (magnetic body) as a hyperbolic tessellation. The fundamental realization of the genetic code would rely on a completely unique hyperbolic tessellation known as icosahedral tessellation involving tetrahedron, octahedron and icosahedron as the basic units [L108, L144]. This tessellation could define a universal genetic code extending far beyond the chemical life and having several realizations also in ordinary biology.
- (d) The number of neurons in the brain is estimated to be about 86 billions: $10^{12} \simeq 2^{40}$. If cell replications correspond to an iteration of a polynomial of degree 2, morphogenesis involves 40 replications. Human fetal cells replicate 50-70 times. Could the m almost copies of the basic system define a region of M^4 corresponding to genes and cells? Could our body and brain be this kind of quantum coherent system with a very large number of almost copies of the same basic system. The basic units would be analogs of monads of Leibniz and form a polymonad. They could quantum entangle and interact.
- (e) If $n = h_{eff}/h_0$ corresponds to the dimension n_E of the extension, it could be of the order 10^{14} or even larger for the gravitational magnetic body (MB). The MB could be associated with the Earth or even of the Sun: the characteristic Compton length would be about .5 cm for the Earth and half of the Earth radius for the Sun).

Could this give a recipe for building geometric and topological models for living organisms? Take sufficiently high degree polynomials f_1 and f_2 and find the corresponding 4-surface from the condition that they vanish. Holography=holomorphy vision would also give a model for the classical time evolution of this system as classical, and not completely deterministic realization of behaviors and functions. Also a quantum variant of computationalistic view emerges.

11.2.3 Zero energy ontology

Zero energy ontology (ZEO) [K146] [L89, L112] is a further key notion of TGD and of TGD inspired biology and consciousness theory.

- (a) In ZEO quantum states as time= constant snapshot are replaced with a superposition of space-time surfaces as preferred extremals analogous to Bohr orbits.

In biology and neuroscience functions and behaviors as precise time sequences are typical and have preferred extremals realized as a minimal 4-surface with singularities as space-time correlates. Genes would not code only 3-D structures but also their time evolutions, which would be dictated by 3-D initial values (3-surface) by Bohr orbit property.

The motivation for the notion of morphogenetic field indeed is that biological processes look like computer programs or even better sequences of planned actions, rather than stochastic processes.

- (b) ZEO leads also to a new view about state function reduction (SFR) solving the basic problem of the standard quantum measurement theory. The basic prediction is that time reversal occurs in ordinary ("big") SFRs (BSFRs) but not in "small" SFRs (SSFRs) which replace the repeated measurement giving rise to the Zeno effect. The sequence of SSFRs correspond to the flow of consciousness for self as a conscious entity. Any un-entangled system can be regarded as self whose life corresponds to a sequence of SSFRs ending with BSFR changing the arrow of time and meaning reincarnation of self [L99, L103].

The basic implication of ZEO is that BSFRs in even macroscopic scales for subsystems look like deterministic classical time evolutions for the observer with opposite arrow of time [L82] and Minev *et al* indeed observed this in atomic scales [L82]. No transition zone from quantum to classical is needed. For instance, there is evidence that earthquakes could be regarded as macroscopic BSFRs.

This has also implications for the dynamics of DNA, in which time reversals might play a key role [L168, L169]. Quite generally, the phenomenon of quantum tunnelling could involve two sub-sequent BSFRs and tunnelling would correspond to a temporary change of the arrow of time [L116, L112].

- (c) The possibility of time reversal forces to generalize thermodynamics and leads to a generalization of second law. Time reversed subsystem obeys second law in reversed time directions and from the point of view of the system breaks it. This suggests a new mechanism of self-organization (in particular biological) as time reversed dissipation taking place spontaneously rather than as a result of intricate programming as in a computationalistic framework. This suggests a new view about homeostasis [L170].
- (d) ZEO based theory of consciousness can be regarded as a generalization of quantum measurement theory based Negentropy Maximization Principle (NMP) [K73] [L109], which involves, besides ordinary entropy with matter, the p-adic entropies assigned with cognition which can be negative and tend to be so by NMP. The theory is consistent with the second law and explains the paradoxical looking findings of Jeremy England that biosystems seem to be maximal entropy producers.

11.2.4 Quantum criticality of TGD Universe

The notion of quantum criticality of TGD Universe was originally inspired by the question about how to make TGD unique if Kähler function $K(X^3)$ in WCW is defined by the Kähler action for a preferred extremal $X^4(X^3)$ assignable to a given 3-surface. Vacuum functional defined by the exponent of Kähler function is analogous to thermodynamical weight and the obvious idea with Kähler coupling strength taking the role of temperature. The obvious idea was that the value of Kähler coupling strength α_K is analogous to critical temperature so that TGD would be more or less uniquely defined. α_K is expected to have several values.

The precise meaning of quantum criticality is far from obvious. The recent progress in understanding the number theoretical aspects has however led to a considerable progress in this respect [L128].

- (a) The exponent $\exp(-K)$ of Kähler function K is the action for the preferred extremal (PE) as a space-time surface in H . PE has 3-surfaces X^3 and Y^3 as its ends at the boundaries of causal diamond ($CD = cd \times CP_2$) of H .
- (b) Ideal holography would mean that Y^3 is fixed once X^3 is known. PEs are however not completely deterministic but analogous to soap films with frames, which are known to allow non-determinism in the sense that frame does not define the soap film uniquely [L121, L128]. Hence X^3 does not fix Y^3 completely but there is a finite number of alternatives for given X^3 .
- (c) X^3 at the passive boundary of CD corresponds to a maximum of K under variations of X^3 in accordance with its passive character. Note that the WCW metric has zero modes not appearing in the metric of WCW so that the maxima could correspond to different values of zero modes. These could define the analog of spin glass energy landscape. Also transitions transforming zero modes to non-zero modes and vice versa are possible.
- (d) Y^3 at the active boundary of CD corresponds to a more general extremum of K with respect to variations of Y^3 , a saddle point. This means criticality. The criticality corresponds to the classical non-determinism of preferred extremals. This leads to a vision about WCW homology as a generalization of Floer homology and characterizing the non-determinism of the action [L128].
- (e) The sequence of SSFRs can be seen as a process leading from a saddle point towards maximum of K , somewhat analogous to the thermodynamical process leading to a thermal equilibrium as maximum of entropy. The non-determinism of SSFRs has as a correlate the classical determinism of preferred extremals.

It is now clear that the values of α_K is determined by the extension of rationals determined by polynomial P [L90, L91, L122, L123, L128].

- (a) Space-time region $X^4 \subset H$ is the image of a 4-surface of M^8 under $M^8 - H$ duality. The 4-surface in M^8 is determined by a polynomial P and by holography which actually defines the $M^8 - H$ duality explicitly.
- (b) The vacuum functional $\exp(-K)$ for a maximum of K must be equal to number theoretical quantity associated with P . The most natural candidate is the discriminant D of P which is the product of squares of root differences for P : $\exp(-K) = 1/D$. This condition predicts a spectrum of α_K appearing in K . p-Adic prime corresponds to the large primed dividing D .

11.3 Basic ideas of TGD inspired quantum biology and theory of consciousness

This section summarizes in more detail the ideas and concepts relevant for TGD inspired theory of consciousness and quantum biology.

11.3.1 Quantum criticality in biology

Quantum criticality [K36, K37, K38, K39] has become key concept of quantum TGD and TGD inspired biology. Quantum criticality allows to understand the hierarchy of Planck constants and also its relationship to p-adic length scale hypothesis, whose origin reduces to number theoretic vision about TGD [K140]. Dark matter phases characterized by $h_{eff} = n \times h$ accompany any quantum critical system, maybe even thermodynamically critical systems. The challenge is to find concrete realizations of quantum criticality in various scales. In biology biochemical realization is of special interest.

The basic aspect of quantum criticality is that the increase of h_{eff} occurs *spontaneously* since the process corresponds to increase of negentropy and NMP states that negentropic entanglement resources of the Universe are increasing as kind of Akashic records or cosmic library. At the level of selves this means that self "dies" and re-incarnates as its time reversal. Selves fight for survival and try to grow their negentropic resources to satisfy the requirements of NMP. This leads to metabolism and homeostasis characterizing living systems. The emergence of life would not be extremely rare accident but doomed to occur spontaneously sooner or later by basic law telling what happens in state function reduction in TGD Universe obeying Zero Energy Ontology (ZEO). Hence the process should occur spontaneously and increase h_{eff} .

- (a) The basic question is how quantum criticality is realized biochemically. Are the molecules excited near to a critical energy at which a dark ion at magnetic flux tube is generated and a phase transition analogous to that leading from ordinary to fourth phase of water occurs? Or are large systems near criticality to a generation of dark phase as the general vision about quantum criticality of TGD Universe suggests.
- (b) A natural assumption is that metabolic energy quantum should be able to induce the phase transition producing dark particles at criticality. Could dark photons in visible and UV range accompany criticality at the level of single molecule? Are cell membrane and neuronal membrane quantum critical systems and how they differ?
- (c) Dark variants of biologically important ions residing at magnetic flux tubes are in fundamental role in TGD inspired quantum biology. In particular, dark proton states are proposed to give rise to the dark analogs of DNA, RNA, amino-acids, and tRNA. The pairing of ordinary DNA/RNA/amino-acids with their dark analogs is expected to be fundamental in biology and transcription and translation are proposed to take place at dark level as the recent experimental findings indicate. How is this pairing realized? How ordinary DNA becomes paired with dark DNA or is it already paired with it?

11.3.2 MB carrying dark matter as controller of ordinary biomatter

MB contains dark matter identified, as phases of ordinary matter characterized by EQ with a dimension $n = h_{eff}/h_0$ serving as a measure of the algebraic complexity of a given space-time region [L90, L91], and interpreted as a universal IQ. The scales of quantum coherence increase with h_{eff} . The layers of MB characterized by the value of n naturally form a master-slave hierarchy in which ordinary matter with the smallest Planck constant is at the bottom, and controlled by higher levels. The energies of systems increase with h_{eff} and since h_{eff} tends to be spontaneously reduced, an energy feed is needed to preserve the distribution of h_{eff} : the interpretation is as an analog of a metabolic energy feed.

MB acts as a "boss" controlling ordinary matter and induces self-organization [L87].

Anatomy of MB

MB has, as its body parts, magnetic flux quanta: flux tubes and flux sheets. There are two kinds of flux quanta. Flux can be vanishing, which corresponds to a Maxwellian regime. Flux can also be non-vanishing and quantized corresponding to a monopole flux. In the monopole case, the magnetic field requires no current for its creation. This option is not possible in the Maxwellian world. By fractality of the TGD Universe, these flux tubes play a key role at all scales [L83].

Also the Earth's magnetic field with nominal value of $B_E = .5$ Gauss has two parts.

- (a) The monopole flux part (see **Fig. ??**) corresponds to the "endogenous" magnetic field $B_{end} = .2$ Gauss and explains the strange effects of ELF EM radiation on the physiology and behavior of vertebrates [J31].

The presence of this part explains the stability of the Earth's magnetic field. This field should have decayed long ago in a Maxwellian world since it is generated by currents which disappear. The contribution of the molten iron in the Earth's core to B_E decays but the changes of the orientation of B_{end} regenerate it [L31]. Also, magnetic fields that penetrate super-conductors as quantized fluxes and even those of permanent magnets (as opposed to electromagnets) may have a monopole part consisting of flux quanta.

- (b) The interaction of MB with the gravitational field of Earth is discussed in [L119]. Intriguingly, the metabolic energy currency with the nominal value of .5 eV is rather close to the energy for the escape velocity of a proton. Could the transfer of ions from the surface of the Earth to MB be a standard process?

Evidence for dark charged particles

The notion of dark matter as a controller of biomatter preceded its justification based on number theory [L56, L55].

- (a) The values of $h_{eff} = nh_0$ must be so large that the energies $E = h_{eff}f$ of dark photons with EEG frequencies are in the biophoton energy range (visible and UV) assignable to molecular transitions [K17, K26].
- (b) What makes the large values of h_{eff} possible? Nottale's hypothesis [E2] introduces the notion of the gravitational Planck constant $\hbar_{gr} = GMm/v_0$, whose form is fixed by an Equivalence Principle (EP). In the TGD framework, $h_{eff} = \hbar_{gr}$ is assigned to gravitational flux tubes [L62]. There are non-trivial implications that reflect EP.
 - i. The cyclotron energy spectrum $E_c = n\hbar_{gr}eB/m = nGMeB/v_0$ does not depend on the mass m of the charged particle and is thus universal. The energies involved are proposed to be in the range of biophoton energies (at least) suitable for control of the transitions of the bio-molecule. One cannot exclude lower energies above thermal energy for physiological temperature.
 - ii. The gravitational binding energies of a mass m for Bohr orbits around M do not depend on M at all [L119].

Also relatively small values of h_{eff} are possible.

- (a) Electrons can also have dark phases, but now the value of h_{eff} would be much smaller and satisfy the generalized Nottale hypothesis $h_{eff} = h_{em}$, where h_{em} is the electromagnetic analogue of \hbar_{gr} assignable to flux tubes accompanying valence bonds. This inspires a model of valence bonds [L51] predicting that the value of $h_{eff}/h_0 = n = h_{em}$ increases along the rows of the Periodic Table.

This picture can explain why molecules such as proteins containing atoms towards the right end of the rows of the Periodic Table are ideal carriers of metabolic energy. It also explains why ions, such as Ca^{++} involved with the control and communications of the cell membrane with the "large" part of MB and having very large $h_{eff} = \hbar_{gr}$, are towards the left end of the rows.

- (b) The energy scale of dark variants of valence electrons is proportional to $1/h_{eff}^2$ so that the orbital radii are scaled up and the identification as a Rydberg atom provides the only possibility in the standard physics model. Could dark valence electrons be in question? There is empirical evidence, known for decades, for the mysterious disappearance of valence electrons of some rare earth metals in heating. An article by Chatterjee *et al* [L53] discusses this phenomenon for Yb.

The finding [D22] about "misbehaving" Ruthenium atoms also supports the view that covalent bonds involve dark valence electrons. Pairs of Ru atoms were expected to transform to Ru dimers in thermo-dynamic equilibrium but this did not happen. This

suggests that valence electrons associated with the valence bond of Ru dimers are dark in the TGD sense and the valence bonded Ru dimer has a higher energy than a pair of free Ru atoms.

TGD based explanation [L53] could be justified by a resonant coupling of dark electron with an ordinary Rydberg state of the valence electron. In the lowest approximation, dark valence electrons have energies in the spectrum of ordinary valence electrons so that a resonant coupling with Rydberg states can be considered. The evidence found by Randell Mill [D23] for atoms with an abnormally large scale of binding energy suggests the formula $h = 6h_0$ [L38]. Atomic binding energies are proportional to $1/h_{eff}^2$ and Mills reports that the binding energy scale can be 4 times larger than for ordinary atoms. This would correspond to $h_{eff} = h/2$.

Pollack effect

In the Pollack effect (PE) [?] negatively charged exclusion zones (EZs) are induced at the boundary between the gel phase and water by an energy feed such as IR radiation. The negative charge of EZ is explained as a formation of flux tubes carrying dark protons, which are interpreted as dark nuclei. Every 4th proton should transform to a dark proton transferred to the flux tubes to explain the observations.

A simple model for linear dark proton triplets predicts their states to be in a 1-1 correspondence with DNA, RNA, tRNA, and amino-acids and the numbers of codons coding for given amino-acid are predicted to be the same as for the vertebrate genetic code [L61, L81]. This suggests deep connections between nuclear physics and condensed matter physics, chemistry, and biology, which, in the reductionistic spirit, are considered separate disciplines.

EZs are able to remove impurities from their interior in conflict with the second law of thermodynamics (SL). The TGD based explanation is that the time reversal by BSFR at the level of MB [L89] also induces an effective time reversal in long time scales at the level of ordinary bio-matter.

PE explains the occurrence of a charge separation in living matter. DNA has one negative charge per nucleotide, microtubules are negatively charged, the cell is negatively charged, and ATP carries 3 units of negative charge. Therefore ZEO suggests that PE plays a key role in bio-control and macroscopic SFRs play a key role in living matter.

Basic differences between organic and in-organic matter

One of the basic differences between organic and in-organic matter would be the presence of dark protons and electrons.

- (a) The notions of acids and bases would reduce to the presence of dark protons: pH would characterize the fraction of dark protons. Reduction and oxidation (the REDOX reaction) could be understood in terms of a transfer of dark electrons associated with valence bonds [L173].
- (b) In biochemistry the density of dark protons would be much higher in PE [I126, I125, L25, ?, ?]. Dark ions could play a key role in TGD based view of biochemistry as the findings of Blackman and others suggest [J31].

Biocatalysis and water memory

Bio-catalysis and water memory [L17] remain mysteries in the bio-chemical approach. MB carrying dark matter could provide the needed mechanisms. Reconnection of flux tubes would be the basic mechanism of bio-catalysis and also explain water memory, which in the TGD framework forms the basis of the immune system [K58].

- (a) According to the TGD view of catalysis, tentacle-like U-shaped flux tubes associated with MBs of reactants reconnect to a pair of flux tubes connecting the molecules [L70]. This happens if there is a cyclotron resonance for dark cyclotron radiation assignable to massless extremals (MEs) associated with these “tentacles”. This requires that the flux tubes have identical magnetic field strengths and - by flux quantization - the same thickness. The same value of h_{eff} guarantees resonance. The next step is the shortening of the “tentacles” by a reduction of h_{eff} and the liberation of energy which “kicks” the reactants over the potential wall making an otherwise extremely slow process possible.
- (b) The physics of water is plagued by anomalies [L17]. TGD suggests an explanation [L59] in terms of flux tubes assignable to hydrogen bonds [L59, L72]. These flux tubes could have $h_{eff} > h$ so that these flux tube could be long and give rise to long range quantal correlations. Water could be seen as a many-phase system. MBs assignable to water molecule clusters could mimic the cyclotron frequency spectrum of the invader molecule and make possible water memory and a primitive immune system based on reconnections of the “tentacles” of a water cluster and invader molecule [L97]. In this framework water would represent a primitive life form.

Comorosan effect

Comorosan effect [?, I65] demonstrates rather peculiar looking facts about the interaction of organic molecules with visible laser light at wavelength $\lambda = 546 \text{ nm}$, which corresponds to photon energy 2.27 eV. As a result of irradiation molecules seem to undergo a transition $S \rightarrow S^*$. S^* state has anomalously long lifetime and stability in solution. $S \rightarrow S^*$ transition has been detected through the interaction of S^* molecules with different biological macromolecules, like enzymes and cellular receptors. I have discussed Comorosan effect in [K145] but the discussion reflect the state of TGD for decades ago.

The typical result in the enzyme-substrate interaction is represented by the enhancement of the enzymic rate, when the respective enzyme substrate is previously irradiated for certain sharply defined times. These *efficient (irradiation) times* are enzyme dependent and can also depend on the biological origin of the enzyme.

The *intensity of laser light does not matter*. What is needed is that the intensity is above certain threshold. The original explanation in terms of saturation of effect (for large intensities of laser light the effect of laser light on organic molecules does not depend on the intensity) has turned to be unsatisfactory.

The effective times are always of the following type $t_i = i * 5 \text{ sec}$, where i is certain integer. The general formula for the effective times is $t_k = t_m + (k - 1)\tau_n$, $k = 1, 2, \dots, 6$, where t_m is the minimum radiation time inducing the first effect and τ_n is the period between two consecutive effects [?, I65]. $t_m = m_E t_1$ and $\tau_n = n_E t_1$ are multiples of the basic time scale $t_1 = 5 \text{ sec}$: $t_k = (m_E + (k - 1)n_E)t_1$. The integers m_E and n_E can be regarded as enzyme characteristics, depending however on the biological origin of the enzyme.

Consider the specific enzymic interaction $E + S \leftrightarrow ES \leftrightarrow E + P$, where E stands for enzyme, S for substrate and P interaction product. Assume that substrate S is subject to a sequence of distinct irradiations lasting for times t_a, t_b, \dots . The following rules are found to hold true.

- (a) The irradiations of the substrate performed after an irradiation with efficient time have no effect on the enzyme-substrate interaction.
- (b) Any arbitrary irradiation of the substrate with irradiation time less than sixth efficient time t_6 performed prior to any other efficient time, is irrelevant for the enzyme-substrate interaction.
- (c) Any arbitrary irradiation of the substrate lasting more than the sixth efficient time t_6 and performed prior to an efficient time precludes all other subsequent effects in enzyme-substrate interaction.

- (d) Note that the time scales 5, 10, 20 seconds have been observed in the clustering of RNA polymerase molecules [I79] discussed from TGD view point in [L63].

The work of Comorosan demonstrates that all irradiation times have nontrivial effect on organic molecules but that for effective times something very special must occur. One should understand what this “very special” is, derive Comorosan formula from a physical model and find a physical interpretation for the integers m_E and n_E appearing in the formula as well as explain the special role of $t > t_6$ irradiation times.

Comorosan effect suggests that communications to MB could take place even at the level of relatively simple biomolecules. One can get some grasp about the situation by considering simplest possible picture that one can imagine.

- (a) It seems that laser light keep care that a connection from the system MB is generated and preserved a critical time for the phase transition to take place. The phase transition itself could correspond to increase of \hbar_{eff} . The problem is to understand why the intensity of laser light does not manner. This suggests that the flux tube can receive the energy of the laser light energy with some fixed rate depending on the enzyme. The receiver could be the MB of enzyme and that it has a dead time after the receival of quantum of laser light.
- (b) The proposal is that Josephson junctions are involved and the Josephson frequency $f_J = ZeV/\hbar_{eff}$ defines the time scales in question.
- (c) The assumption $\hbar_{eff}/\hbar = \hbar_{gr}/\hbar = GMm/v_0 = 2r_s(E)m/v_0$, where $M = M_E$ is the mass of Earth, $r_s(E) = .09$ m and $m = 2m_e$ as mass of electron Cooper pair, m_e is electron mass, allows to estimate the parameter $\beta = v_0/c$ assuming $f_J = E_J/\hbar_{gr}$ is equal to Comorosan frequency $f_C = 1/T_C = .2$ Hz. For Josephson energy $E_J = 2eV \simeq .1$ eV of electron Cooper pair, this gives the estimate $\hbar_{gr}/\hbar \simeq 5 \times 10^{13}$. The value of β_0 would be $\beta_0 \simeq .93$ near its maximal value. This estimate is consistent with the estimate of [L115].
- (d) There are two especially important cyclotron frequencies in endogenous magnetic field B_{end} with nominal value .2 Gauss.
 - i. The cyclotron energy $E_c = \hbar_{gr}ZeB_{end}/m$ of a charged particle does not depend on its mass. For Fe^{++} ion f_c in the endogenous magnetic field $B_{end} = 2B_E/5 = .2$ Gauss equals alpha frequency $f_c(Fe^{++}) = f_\alpha = 10$ Hz. Cyclotron energy $E_c(Fe^{++}) = \hbar_{gr}f_c = 2.5$ eV. Note that this energy is not far from the energy 2.27 eV of photons in the experiments of Comorosan suggesting that they were in energy resonance with dark Josephson photons or were in energy resonance with them. For $\beta_0 = 1$, one would have $E_c(10Hz) = 2.44$ eV. For $E_c = 2.24$ eV one would obtain $\beta_0 = 1.024 \geq 1$. Scaling of 10 Hz alpha frequency to 9.3 Hz would allow $\beta_0 = 1$ and $E = 2.27$ eV.
 - ii. DNA cyclotron frequency $f_J(DNA)$ is another probably very important frequency. It depends only weakly on DNA length and the base-pair it has has average value 1 Hz which corresponds to energy .244 eV. This is roughly 1/2 of the metabolic energy quantum.
 - iii. To sum up, for $\beta_0 = 1$, one can relate to each other $f_C, f_J(Fe^{++}, B_{end})$ and $f_J(DNA, B_{end})$, and the corresponding cyclotron energies and the value of the membrane potential.

This model alone does not explain much. What happens looks like an outcome of a control action and should take place at the level of MB: the irradiation affects the MB of the E+S complex, which responds at times t_k . One can also assume the TGD inspired view about biocatalysis and look at what this gives.

- (a) The time $t_1 = 5$ s need not correspond to dark Josephson time for a given enzyme for which has 6 special irradiation times $t_k = t_m + (k_1)\tau_n$, $k = 1, \dots, 6$, which are multiples $n_k t_1$ of t_1 . This would scale up h_{gr} by n_k and v_0 would be scaled to v_0/n_k . Therefore one would have a spectrum of $v_0 = 1/n$, with each enzyme allowing 6 different values of n . t_1 would be minimal Josephson time corresponding to maximal $v_0 = c$.

- (b) What could happen in the transition at t_k ? Why certain multiples $n_k t_1$ would define thresholds at which enzyme activity increases? Could one interpret this in terms of MB controlling the E+S complex?

At these specific moments enzyme action would be affected. If enzymatic action involves a reduction of h_{eff} for flux tubes connecting E and S, one might think that the Δh_{eff} increases and more energy is provided to overcome the potential wall slowing down the reaction. Reaction becomes faster.

- (c) Could the irradiation induce phase transitions increasing the h_{eff} for these flux tubes. Could these flux tubes be the flux tubes with $h_{eff} = h_{gr}$ and could the phase transition change the value of $v_0 = 1/n$ to new subharmonic and scale h_{gr} by n . The length of flux tubes would increase and the energy liberated in the shortening would be proportional to $\Delta h_{gr} \propto \Delta n$.

The irradiation corresponds to $f_c(Fe^{++} = 2.27$ eV all the time. If an increasing value of h_{gr} is associated with catalyst flux tubes, alpha frequency must be changed to is sub-harmonic $f_c(Fe^{++}/n$ in each phase transition bringing in longer length scales.

- (d) Why the transitions should take at such precise values t_k of time characterizing the enzyme? h_{gr} has a number theoretic origin that reflects the polynomial deterministic dynamics at the level of M^8 analogous to Bohr orbit dynamics at the level of H . If quantum non-determinacy has the failure of string determinism for the space-time surface as 4-D soap films with frames as a correlate, one would expect that these phase transitions occur deterministically. One can also ask whether quantum jumps replace polynomial P with a new one.

Could the times t_k correspond to SSFRs or to the pairs of BSFRs giving rise to quantum tunnelling between the different phases at MB?

Why should t_k be some integer multiples of t_1 . What comes to mind is time crystal structure associated with the 4-D soap film with frames.

- (e) Threshold effect could be in question. The irradiation could play the role of metabolic energy feed. This might help to understand why the phase transitions occur at times t_k . For instance, the irradiation could transfer dark electrons at flux tubes as in the Pollack effect. It could also induce a phase transition of Bose-Einstein (BE) condensate at the magnetic body of the enzyme (phase transition of a spin glass-like structure analogous to spontaneous magnetization). The obvious possibility is the BE condensate of electron Cooper pairs. The increase of h_{eff} requires energy and when some minimum energy is feeded, the transition occurs.

- (f) Could laser photons be transferred to the flux tube photons with a rate determined by the flux tube alone as a slow step of the process, where it forms an dark N-photon state. N would increase steadily and when the energy of this state exceeds a threshold defined by the Josephson energy $E_J = 2ZeV$ a Cooper pair is created, which means that MB sends an ordinary photon with this energy to the aromatic ring and kicks out a Cooper pair. The number of laser photons would be such that the energy exceeds the binding energy of p^2 electron pair in the aromatic ring. A rough estimate for this energy as $E \simeq 2(Z^2/n^2)E_H$, $E_H = 13.6$ eV would be about 122.3 eV and gives $N \geq E/22.7 \geq 54$.

- (g) Why the number of transitions is 6? Could this relate to aromatic 6-ring as a basic object? The electron configuration of C is $[He]2s^2 2p^2$. There is one p^2 state as an candidate of the Cooper pair for each Carbon atom. Could the 6 steps correspond to a sequence of transitions in which one p^2 state becomes a dark Cooper pair.

Could base pairs act as Josephson junctions?

The basic idea is that each system has a "biological body" (BB) and MB and that BB sends sensory data to MB which in turn controls it. The idea about nuclear membrane as a communicator of sensory data to MB using dark Josephson radiation looks attractive. Is it enough to send the sensory data from the nuclear membrane only? Or could the sensory data from DNA be sent along flux tubes to the nuclear membrane to MB? Or could it be sent directly from DNA? The idea of base pairs as Josephson junctions need not be realistic but deserves to be shown wrong, if not anything else.

- (a) The sensory communication from DNA using a series of base pair Josephson junctions should utilize dark genetic code based on 3N-photons fused by Galois confinement to longer units like genes. The frequency triplet, 3-chord, must be different for codons, which differ only by the order of letters. This is impossible if one assumes that the letters are independent. The process of adding letters to codon and codons to DNA sequence must be non-commutative and one can speak of a well-defined order. This order naturally corresponds to the orientation of DNA strands.

- (b) In the number theoretic vision, many particle systems correspond to space-time sheets, which are obtained by $M^8 - H$ duality from a 4-surface of M^8 obtained by holography from the roots of an octonionic continuation of a real polynomial P with rational coefficients. P is obtained as a non-commutative functional composition of real polynomials.

The spectrum of the roots has an interpretation as quantized virtual mass squared values specifying the mass shells $H^3 \subset M^4 \subset M^8$, which define holographic data. The root spectrum of a composite depends on the order of polynomials in the composite.

The letters A,T,C,G of codon could correspond to 4 different polynomials P_i , $i = 1, \dots, 4$ and codons would be composites of form $P_i \circ P_j \circ P_k$. If the order of functional composition corresponds to the orientation of the strand, it would be opposite for strand and conjugate strand and the 4-surfaces corresponding to strand and conjugate strand would not be simply the same surface but with opposite direction. Only for palindromes, the base pairs A-T and T-A (C-G and G-C) at the opposite ends of the double strand are equivalent if the picture based on polynomial composition is correct. This could explain the different biological roles of strands. Also the halves of many binary structures of biology, such as brain hemispheres could have a similar relationship.

- (c) Base pair would give rise to a basic Josephson junction between aromatic rings acting as superconductors. These elementary Josephson currents would integrate to to 3N-Josephson junction as a quantum coherent unit. The emitted Josephson photons would be dark 3N-photons analogous to BE condensates.
- (d) The delocalization of protons in the hydrogen bonds of base pairs A-T and C-G would take place. In the delocalization the proton tends to shift to the direction of the atom to which hydrogen bonding takes place. Protons generate a polarization creating an electric field in which electron Cooper pairs move but at different space-time sheets than protons. This would produce oscillatory Josephson current emitting Josephson photons [K96]. The dark electron Cooper pair currents would originate from the aromatic rings. Note that the Josephson voltage would be the same along all space-time sheets.
- (e) The pairing of aromatic rings by hydrogen bonds need not be the only way to create dark Josephson junctions. Also Josephson junctions between hydrogen bonded molecules without any aromatic rings can be considered. Pollack effect creates negatively charged exclusion zones (EZs) in water. The protons would be transferred to dark proton sequences at the flux tubes whereas the electrons of EZ would form dark electron Cooper pair condensates generating Josephson currents and Josephson radiation perhaps making possible communications between these systems.
- (f) An estimate for the Josephson voltage is obtained by assuming that the Josephson voltage scales as the inverse of the size scale of the basic object. For neuron membrane

of thickness $D=10$ nm (for cell membrane the thickness is nearer to 5 nm) is replaced with A-T or C-G pair with thickness of $d=.34$ nm. This gives an estimate for the energy $E_J = 2eV$ of Cooper the estimate $E_J = (D/d) \times .01 \text{ eV} = 3.3 \text{ eV}$ (1.75 nm). This energy looks rather reasonable. Interestingly, this is not too far from the energy 2.27 eV associated with the laser photons inducing the Comorosan effect already discussed.

In Comorosan effect [?, I65], the irradiation with a laser beam with a photon energy $E_J = 2.27 \text{ eV}$ would generate the BE condensate of dark Cooper pairs. This might be true also for the base pairs. This should be testable.

Biosystem as a spin glass like system

Spin glasses represent an exotic phenomenon, which remains poorly understood in the standard theoretical framework of condensed matter physics. Actually, spin glasses provide a prototype of complex systems and methods used for spin glasses can be applied in widely different complex systems. Biology is certainly one the most interesting applications.

In [L113] a TGD inspired view about spin glasses is discussed.

- (a) TGD view about space-time leads to the notion of magnetic flux tubes and magnetic body. Besides spins also long closed magnetic flux tubes would contribute to magnetization. The basic support for this assumption is the observation that the sum of the NFC magnetization and the FC remanence is equal to the NFC magnetization. Magnetic field assignable to spin glass would correspond to a kind of flux tube spaghetti and the couplings J_{ij} between spins would relate to magnetic flux tubes connecting them.
- (b) Quantum TGD leads to the notion of "world of classical worlds" (WCW) and to the view about quantum theory as a "complex square root" of thermodynamics (of partition function). The probability distribution for $\{J_{ij}\}$ would correspond to ground state functional in the space of space-time surfaces analogous to Bohr orbits.
- (c) Spin glass is a prototype of a complex system. In the TGD framework, the complexity reduces to adelic physics fusing real physics with various p-adic physics serving as correlates of cognition. Space-time surfaces in $H = M^4 \times CP_2$ correspond to images of 4-surfaces $X^4 \subset M_c^8$ mapped to H by $M^8 - H$ duality. X^4 is identified as 4-surface having as holographic boundaries 3-D mass shells for which the mass squared values are roots of an octonionic polynomial P obtained as an algebraic continuation of a real polynomial with rational coefficients. The higher the degree of P , the larger the dimension of the extension of rationals induced by its roots, and the higher the complexity: this gives rise to an evolutionary hierarchy. The dimension of the extension is identifiable as an effective Planck constant so that high complexity involves a long quantum coherence scale.

The TGD Universe can be quantum critical in all scales, and the assumption that the spin glass transition is quantum critical, explains the temperature dependence of NFC magnetization in terms of long range large \hbar_{eff} quantum fluctuations and quantum coherence at critical temperature.

- (d) Zero energy ontology predicts that there are two kinds of state function reductions (SFRs). "Small" SFR would be preceded by a unitary time evolution which is scaling and generated by the scaling generator L_0 . This conforms with the fact that relaxation rates for magnetization obey power law rather than exponent law. "Big" SFRs would correspond to ordinary SFRs and would change the arrow of time. This could explain aging, rejuvenation and memory effects.
- (e) Adelic physics leads to a proposal that makes it possible to get rid of the replica trick by replacing thermodynamics with p-adic thermodynamics for the scaling operator L_0 representing energy. What makes p-adic thermodynamics so powerful is the extremely rapid convergence of Z in powers of p-adic prime p .

Is there an analogy between dark information molecules and spin glasses?

- (a) The TGD based model for spin glass involves dark flux tubes with a local magnetization and the state could be seen as a kind of flux tube spaghetti. Also the dark variants of basic information could be seen as this kind of flux tube structures.

Quantum criticality of TGD suggests that the flux tube configuration has a large number of energy degenerate states and that this is essential for morphogenesis controlled by counterparts of dark genes. In fact, the huge non-determinism of Kähler action due to the existence of vacuum extremals with a CP_2 projection, which is Lagrangian manifold, led to the notion of 4-D spin glass. Twistor lift removes the non-determinism and reduces degeneracy by adding to the action a small volume term, whose coefficient is proportional to a length scale dependent cosmological constant. 4-D spin glass degeneracy is expected to reduce to 3-D spin glass degeneracy.

- (b) Spin and weak isospin distinguishing between dark neutron and proton are in a key role in the proposed model for the dark nucleon realization of the genetic code [L141]. Codons correspond to closed flux tubes containing 3 dark nucleons connected by pion-like flux tube contacts. The states of this object give rise to dark information molecule DX paired with X, X=DNA, RNA, tRNA, and AA. The states correspond to tensor products of spin-isospin states in representation $4_I \times 4_s$ of 3 dark nucleons with the angular momentum state of string-like flux tube possessing orbital angular momentum L and correspond to $5 \oplus 3$ (spin 2 and spin 1) for DDNA, DRNA and DtRNA and singlet 1 for DAA as representations of rotational group. In spin and nuclear spin degrees of freedom DDNA corresponds to $(1/2, -1/2)_I \otimes 4_s$, DRNA to $(3/2, -3/2)_I \otimes 4_s$ and DtRNA to $2_I \otimes 2_s$. 32 DtRNAs are predicted and this is the minimal number. The pairing of DtRNAs with tRNAs need not be unique.

Remark: Genetic code has a complete (U-C) symmetry and almost complete A-G symmetry with respect to the third nucleotide of RNA codon. These symmetries have an interpretation in terms of rotational symmetry [L141]. What could be the interpretation of purine sequences (A and G) paired with pyrimidine sequences (T and C) in this picture?

Could one understand how the dark information molecules DX (X refers now to DNA, RNA, and proteins P rather than codons and AAs) could control the conformations of X?

- (a) The spin state of the dark codon varies along the flux tube so that dark information molecules as flux tubes carrying various spin states differ from the simple ferromagnetic or antiferromagnetic system locally. In spin glasses, ferromagnetism and antiferromagnetism compete and the notion of frustration meaning that there is a large number of states with the same free energy implies complexity. Still DX is much more complex than spin glasses.

One can however ask, whether the variation of the spin state of DX along the flux tube is analogous to the frustration of spin glasses? Could the total (free) energy of the dark nucleon triplet depend only very weakly on the codon content so that the frustration would be maximal and give rise to a maximal representative power.

- (b) The nuclear spin of the dark nucleon triplet couples with the stringy angular momentum of the closed flux tube of the codon. One can expect similar coupling in longer scales between the total angular momentum of subsequent codons along the flux tube and also with the stringy angular momenta assignable to larger units of DX such as gene, promoter region, or a control region like Alu in the case of DNA. One would have a tensor product of representations of the rotation group for codons and longer basic units. These tensor products decompose to irreps.

Could various irreps in these decompositions correspond to various flux tube configurations for the units of DX, X= DNA, RNA. DAAs have stringy angular momentum

at the level of codons as closed flux tubes. Dark protein (DP) flux tube has angular momentum and it can couple to the angular momenta of DAAs?

Could this coupling make it possible for the units of DX to control the dynamical geometry of the flux tube as phase transitions between different irreps of the rotation group? Could these transitions occur at quantum criticality?

- (c) If this picture is correct, the degeneracy of the angular momentum states of the dark information molecules DX (genes, RNA, proteins) would correspond to a degeneracy of the geometric configurations of information molecules X. DX would serve as a control knob. This is just what a morphogenetic field should achieve. The feed of metabolic energy would induce transitions in the quantum spin glass energy landscape. Also protein/DNA/RNA folding and unfolding induced by energy feed could be understood in this manner.

11.3.3 Communications to and control by MB

Communication from the biological body (BB) to MB and its control by MB would rely on dark photons, which can transform to ordinary photons with a large h_{eff} and vice versa. Molecular transitions would represent one form of control.

- (a) Cell membranes could act as generalized Josephson junctions generating dark Josephson radiation with energies given by the sum $E_J + \Delta E_c$ of ordinary Josephson energy E_J and the difference ΔE_c of cyclotron energies for flux tubes at the two sides of the membrane. The variation of the membrane potential modulates the Josephson frequency and codes the sensory information at the cell membrane to a dark photon signal sent to MB.
- (b) The large effects of radiation at ELF frequencies observed by Blackman and others [J31] could be understood in terms of the cyclotron transitions in $B_{end} = .2$ Gauss if “ h ” in $E = hf$ is replaced with h_{eff} . h_{eff} should be rather large and possibly assignable to the gravitational flux tubes with $h_{eff} = h_{gr} = GMm/v_0$. For the simplest model, M represents the Earth’s mass coupling to the small mass m , and v_0 is a parameter with dimensions of velocity expected to have discrete spectrum. The energies $E = h_{eff}f$ of dark photons should be in the biophoton energy range (visible and UV) characterizing molecular transitions [K17, K26].
- (c) For the value $v_0/c \simeq 2^{-11}$, suggested by the Nottale’s model for planetary orbits [E2], the predicted cyclotron energy scale is 3 orders of magnitude higher than the energy scale of visible photons. Several solutions of this problem were considered [L118]. The most plausible solution [L118, L104] is $\beta_0 = v_0/c = 1/2$ for living matter so that gravitational Compton length $\Lambda_{gr} = GM/\beta_0$ equals to Schwarzschild radius at the surface of Earth and brings nothing new to the original Nottale hypothesis.

Cyclotron photons and Josephson photons as basic tools of control and communication

By its higher level of “IQ”, MB would naturally be the master controlling BB by cyclotron radiation - possibly via a genome accompanied by dark genome at flux tubes parallel to the DNA strands.

- (a) Cyclotron BE condensates (BECs) of bosonic ions, Cooper pairs of fermionic ions, and Cooper pairs of protons and electrons would appear as dark matter in living systems and the $h_{eff} = h_{gr}$ hypothesis predicts a universal cyclotron energy spectrum in the range of bio-photon energies. Dark matter and MB would use the biological body, defined in very general sense since life is a universal phenomenon in TGD, as a sensory receptor and motor instrument. MB would receive sensory input most naturally as generalized dark Josephson radiation and control it by dark cyclotron radiation.

- (b) All charged elementary particles and basic biological ions would have dark variants and could define Josephson currents. Dark photons and BE condensate-like states formed from them would give rise to the analogs of morphogenetic fields. Dark Josephson radiation associated with electrets, which are indeed electric dipolar structures, replaces Fröhlich condensates in the TGD framework.
- (c) The key equation is $f = ZeV/\hbar_{eff}$ which allows to associate low Josephson frequencies with large energies, say the Josephson energy associated with cell membrane to ELF frequency. Second key equation $E_c = \hbar_{eff}f_c = \hbar_{eff}ZeB/m$ assigns to a low frequency, such as EEG frequency, a large cyclotron energy.
- (d) There is a connection with biophotons [I166, I107, ?, I64, I139, I150], which is a phenomenon having no feasible biochemical explanation. In the TGD Universe, biophotons can be regarded as ordinary photons resulting from the transformation of dark photons to ordinary photons in an energy conserving manner [K17, K26]. This dramatically reduces the wavelength and in this manner couples long and short length scales dynamically.

In ZEO, the field body (FB) and MB correspond to 4-D rather than 3-D field patterns and quantum states correspond to quantum counterparts of behaviors and biological functions. Conscious holograms could be generated as a result of interference of a dark photon reference beam from MB and a dark photon beam carrying the sensory information. This hologram would be read by MB using the conjugate of the reference beam. In ZEO time reversals of these processes also take place. This makes it possible to understand memory as a result of communications with memory mental images.

If one accepts the view that dark Josephson radiation is a universal communication tool in communications between biological body and MB, one can ask whether DNA could utilize it. Consider first the situation at the level of the cell membrane.

- (a) Dark generalized Josephson radiation associated with the generalized Josephson junctions defined by membrane proteins would make possible communication of local sensory data to MB [K96, K98, K44]. These Josephson junctions are idealizable as continuous Josephson junctions with a geometry of a cylindrical shell. Ground state would correspond to a soliton sequence and the dark variant of nerve pulse would correspond to a perturbation of the soliton sequence propagating like a nerve pulse.
- (b) The feedback as control actions could take place via genome as transcription of genes or more general gene expression. This would require communications from genome to nuclear membrane to cell membrane perhaps made possible by magnetic flux tubes connecting them. Their braiding would also make possible topological quantum computation type processes [K3, K135, ?].
- (c) This model generalizes to a model for the communications of "sensory" data from nuclear membrane to MB.

One can consider several analogs of Josephson junctions at the level of DNA double strand and even at the level of DDNA.

- (a) One can ask whether the linear structures formed by the electron chains [?, ?, ?] assigned with the stack of aromatic rings and proton chains defined by longitudinal hydrogen bonds inside the DNA double strand form Josephson junctions so that Josephson currents would consist of protons and electrons.
- (b) Could Josephson junctions between base pairs make sense? What is missing is the membrane-like structure and nanoscopic Josephson junctions as analogs of membrane proteins. Base pairs could in principle give rise to Josephson junctions if there is voltage between them. In this case, even the analogs of soliton sequences and nerve pulse could make sense.

- (c) There exists a longitudinal electric field along DNA [L168, L169]. It could be that nucleotides define analogs of Josephson junctions and they might generate collectively dark 3N-photons as generalized Josephson radiation. In this case, the analog of nerve pulse would not make sense.

Control of DNA and other biomolecules by MB

How MB could control the DNA and other biomolecules?

- (a) Suppose that the monopole fluxes of dark DNA strands generate currents flowing in aromatic rings of strands. Also spin magnetization could be induced and this in turn would generate currents in aromatic rings. This could give rise to an analog of magnetized state. Also a diamagnet with vanishing total magnetic field perhaps giving rise to superconductivity is generated.
- (b) The control of the network of formed by the typically linear structures and membranes is an essential part of biosystems in supramolecular scales. Here an analogy with spin glasses is highly suggestive. Spin glass has become a prototype of complex system. They are characterized by a local magnetization with a varying direction. Spin glass landscape has fractal energy landscape having valleys inside valleys and p-adic physics suggests an elegant description of it [L113]. This kind of phase would be ideal control tool used by MB.
- (c) In the TGD framework, spin glass could correspond to a dark magnetized flux tube network. Spin glass phase could couple to biophotons produced from dark cyclotron photons with large \hbar_{eff} transforming to ordinary biophotons of dark photons with a smaller value of \hbar_{eff} and induce transitions between valleys of the energy landscape corresponds to different geometric and topological configurations of flux tubes. Reconnections and changes of flux tube lengths induced by the change of \hbar_{eff} would be basic processes.
- (d) Braiding would make possible topological quantum computation using magnetizations associated with flux tubes as analogs of qubits. These qubits would be highly stable as magnetized multi-spin systems. Entanglement would be between magnetizations instead of spins. The first version of topological quantum computation discussed in [K3, K4, K135] did not yet involve spin glass hypothesis.

11.3.4 Dark counterparts of information molecules and dark realizations of genetic code

There are good reasons to expect that genetic code is something very fundamental and realized at the level of fundamental physics. Genetic code relates to information processing and dark matter at MB has higher "IQ" as the dimension of extension of rationals identifiable in terms of \hbar_{eff} . This leads to two realizations of the genetic code in terms of dark photons and dark nucleons and also strongly suggests that the genetic code is a universal phenomenon having many other realizations besides the biological ones.

Dark analogs of the basic information molecules

The basic information molecules DNA, RNA, tRNA and aminoacids (AA) would have dark counterparts in TGD Universe. DDNA, DRNA, DtRNA, and DAAs would serve as sources of dark 3N-photons representing genes and in special case codons. There would be resonance couplings between DDNA and DRNA, DRNA and DtRNA, DtRNA and DAA. Also resonant coupling change the value of \hbar_{eff} and the frequency by energy conservation $E = \hbar_{eff1}f_1 = \hbar_{eff2}f_2$. If \hbar_{eff} changes there is only energy resonance.

During the interaction, these systems should be quantum critical in order to make control, communication and sensory sensitivity optimal which suggests that temporary transitions to quantum criticality is basic aspect. Since the increase of h_{eff} requires energy, metabolic energy would be needed to achieve these transitions. The layers of MB with different values of h_{eff} forming a slaving hierarchy would couple by energy resonance.

Also the communications and control of the ordinary biomatter by dark biomatter is needed. There must exist couplings between DX and X. DX-X pairing would represent permanent interaction of this kind of interaction. Since $h_{eff} = h$ does not actually correspond to the minimum value h_0 of h_{eff} , it would seem that resonant interaction must be involved. Energy resonance gives strong conditions on cyclotron transition energies of DX and transition energies of X. The transition energies for X should be chemical transition energies.

That biophotons, which could result from dark N-photon, have energies in visible and UV range, conforms with this picture. This would make possible direct control of chemistry. Also transitions changing molecular conformations could be activated: the energies for them are in THz range and analogs of biophotons in microwave range are highly suggestive. Dark N-photon could consist of dark photons with energy corresponding to THz range. Vibrational and rotational transitions could be also activated.

Two realizations of genetic code

TGD inspires the proposal of two dark realizations of genetic code whose most recent forms are discussed in [L141].

- (a) The first realization represents codons as dark nucleon triplets [L61, L81] and the second realization as dark photon triplets that is 3-chords [L22] [L96, L108, L141].
- (b) The models for dark codons generalize to models of genes. Galois confinement predicts that dark N-particles states are possible. In particular, genes could correspond to dark 3N-nucleon states as a bound state of dark 3-nucleons associated with flux tubes parallel to DNA strands and to dark 3N-photon states as analogs of BE condensate.

The communications and control would be based on 3N-resonance in which frequency modulated Josephson radiation would produce a sequence of resonance pulses at MB possibly related to nerve pulses. The genetic codon would determine the address of the receiver as in LISP and modulation would encode for the information transmitted.

- (c) The icosahedral model of the genetic code introduced as a model of music harmony has justification in terms of icosahedral tessellation of the hyperbolic space H^3 defining mass shell [L108]. These mass shells define holography and allow explosion of cognitive representations since all algebraic integers are allowed as points. Genetic code would be therefore universal and could also have 2- and 3-D representations. Even cell membranes could define such a representation.
- (d) One can say that dark matter at MB and Josephson junctions involving the flow of dark ions define morphogenetic fields in the TGD framework and their interactions are based on signals propagating along topological light rays parallel to the flux tubes. N-resonance making possible precise selective receipt of the signals and frequency and amplitude modulation codes for the message.
- (e) The new view about genetic code leads also to a vision about the evolution of language known to be initiated by mutations of only few genes [L171, L172]. The idea is that the value of h_{eff} increases for the highest layers of MBs associated with these genes and led to the cultural evolution which quite generally corresponds to evolution at the level of MB.

To sum up, dark Josephson and cyclotron 3N-photon could define the TGD analogs of morphogenetic fields. The communication would be based on 3N-resonance and information would be coded using frequency and amplitude modulation and would generate a sequence of resonance pulses.

11.4 Water memory

Water memory, or homeopathy, is still not taken seriously by mainstream biologists although the empirical support is unquestionable. In this section I will discuss the findings of Benveniste's group and Montagnier's group from the TGD point of view.

11.4.1 Biological signaling by EM means

Yolene Thomas discusses the history of the notion of water memory in the articles "*The history of the Memory of Water*" [?] in particular the basic findings of Benveniste's group. In [?] further findings are discussed. These findings serve as bench tests for the TGD view.

Basic findings of Benveniste's group

Yolene Thomas worked in the group of Benveniste. Among other things Benveniste had discovered an allergy test using blood cells known as basophils. At 1980's Jacques Benveniste and Bernhard Poitevin started to study homeopathy. Antibodies causing basophil degranulation were added to water. A repeated dilution together with agitation led to a situation in which the concentration of the molecule was extremely low and should have caused any effects. The solution however induced a degranulation of the biomolecule itself. The finding was in conflict with the standard lock-and-key mechanism. The conclusion was that the information about antibodies might have been transferred to solution during dilution/agitation process by some unknown molecular organization.

The results were checked in other laboratories and eventually an article by Benveniste and Poitevin was published in *Nature* but induced violent reactions of skeptics. Instead of a scientific committee, *Nature* sent Magician James Randi and Walter Stewart, a fraud investigator, to the laboratory of Benveniste. They did not find any evidence for fraud. Nevertheless, they concluded that Benveniste had failed to replicate the claimed results.

Although Benveniste became isolated from the community, the research continued.

- (a) It was found that the vigorous agitation involving vortexing was essential for the effect. Pipetting up-and-down did not have the effect.
- (b) The effect was found to occur also for the dilutions of ethanol and propanol but not for dilutions of dimethyl sulphoxide.
- (c) Heating, freeze-thawing or ultrasonication suppressed the activity of highly diluted solutions, but not the activity of several active compounds at high concentrations.

Molecules reacted to heat according to their distinctive heat sensitivity, whereas all highly diluted solutions ceased to be active between 70 and 80 °C. This suggests that the mechanism is independent of the nature of the original molecule.

- (d) It was found that the activity of highly diluted agonists was abolished by the application of 50 Hz magnetic field of strength 150 Gauss for 15 minutes (Earth's magnetic field has strength .5 Gauss and the endogenous magnetic field explaining the findings of Blackman has strength .2 Gauss). There was no comparable effect on original molecules.

What can one conclude from these findings in the TGD framework?

- (a) Vortex formation could correspond to the formation of magnetic monopole flux tubes which provide a representation for the MB of antigen. Also Z^0 magnetic flux tubes could be involved in TGD based hydrodynamics and accompany hydrodynamic vortices [L115]. The agitation could feed kinetic energy as a metabolic energy feed for primitive non-chemical lifeforms generated at the flux tubes.

The different effects of freeze-thawing or ultrasonication effects on the antibody and on the diluted solution supports the view that something representing the antigen in some respects was formed at the flux tubes.

Pollack effect [I126, I125, L25, ?, ?] generating in the presence of say IR radiation negatively charged region as exclusion zones (EZs) suggests that part of protons of water molecules were transferred somewhere.

The TGD based explanation [L25] is the formation of dark proton sequences at the flux tubes as analogs of nuclei at the flux tubes defining a primitive lifeform utilizing IR radiation as metabolic energy source: metabolic energy feed would increase the value of h_{eff} . These life forms would correspond to MBs assignable to water clusters.

The flux tubes of MBs would reconnect with the molecules of the MB of antigen and change their thickness to tune into resonance. In this way they would form representations of antigen by mimicking the cyclotron frequency spectrum of the antigen. They could induce the same effects as antigen if the cyclotron frequencies are a basic control tool of biochemistry. Water clusters would catch the invader molecules. This mechanism would underlie the biochemical immune system and biocatalysis.

One can even ask whether genetic code is realized for these life forms: the restriction of dark nucleon sequences to those consisting of protons gives as outcome 32 codons, the minimum number of tRNA codons.

- (b) The effect occurs for ethanol and propanol but not for dimethyl sulphoxide. Hydrogen bonding requires OH-groups. Ethanol and propanol have OH groups but not dimethyl sulphoxide so that the hydrogen bonding could explain the difference. The proposal indeed is that water allows long hydrogen bonds with non-standard value of h_{eff} containing delocalized proton or even several protons. This can explain the numerous anomalies associated with the thermodynamics of water.
- (c) The 50 Hz oscillatory magnetic field abolished the effect. Note that 50 Hz is a cyclotron frequency of ^7Li in the "endogenous" magnetic field $B_{end} = .2$ Gauss explaining Blackman's findings and interpreted in the TGD framework as magnetic field assignable to monopole flux tubes. Could it be that the reconnection with flux tubes of MB of the antibody catches parts of its MB and also ^7Li ions at it?

Was the mere oscillatory character of the magnetic field essential or does 50 Hz correspond to a cyclotron or Larmor frequency associated with the magnetic flux tubes so that resonance was involved?

For instance, could the resonance have abolished dark proton condensates at the monopole flux tubes as life forms mimicking the cyclotron spectrum of the antigen to flux tubes of external nono-monopole magnetic field? Does 50 Hz frequency belong to the ELF spectrum of the antigen?

Between 1992 and 1996, the group of Benveniste learned to transfer molecules signals, in real time, molecular signals indirectly to water or directly to cells. Cells were placed in a 37 C humidified incubator on one coil attached to the oscillator, while an agonist (or vehicle as control) was placed on another coil at room temperature. In one such exploration, it was found that molecular signals associated with a common phorbol ester could be transmitted by physical means directly to human neutrophils to modulate reactive oxygen metabolite production.

Since 1995 it has been possible to record, digitize, and replay water memory.

Some further findings of Benveniste's group

In the second article "*Biological signaling by EM means* [?]" (<https://cutt.ly/EAe67sy>) Yolene Thomas summarizes some findings of Benveniste's group represented by Benveniste in 1994. The findings were related to cell lines, isolated guinea-pig heart and in vivo in a mouse model.

- (a) Heavy metal poisoning causes serious disorders, either inflammatory or strictly immunological. For the isolated cell lines the effects of Cd at very low doses were studied. For 5-10 μM Cd a high mortality was observed. The pre-treatment with non-toxic doses of HD of Cd with dilution log 16-25 or 26-35 for several days, a significant modulation of cellular activation and growth was observed either directly, both before and after the otherwise lethal concentrations.
- (b) Isolated guinea-pig or rat hearts were perfused at constant pressure in the so called Langendorff system with highly diluted vasoactive amines. ACh, histamine and water above the aorta. Variation in the coronary flow (CF) was observed. Significant effect on CF was observed. Also now the application of 50 Hz magnetic field abolished the effect.
- (c) HD of silica (cytotoxic for macrophages) was applied to mice in vivo. The effect on macrophages was compared for the treated and control mice. The impact on synthesis of paf-aceter, mediator of inflammation and its precursor lyspaf-aceter was studied. Significant differences were observed. Increase in synthesis of paf-aceter was found. No effect on the synthesis of the precursor in the HD sample was detected.

All these findings conform with the water memory interpretation and TGD based model for it.

Results of other groups

Thomas describes also some findings of other groups.

- (a) During the period 1990-1994 Endler studied thyroxine controlled morphogenetic regulation of amphibian *Rana temporaria* in the transition from 2- to 4-legged stage. Animals that were pretreated with HD of thyroxine metamorphosed more slowly. One could interpret this as immunity against the effect of actual thyroxine produced by the organism produced by false thyroxine. Same effect was achieved with electronic circuitry using recorded frequency spectrum with frequencies below kHz.
- (b) Luc Montagnier has studied since 2005 the effect on mycoplasma, HIV and bacteria. Certain bacteria and DNA extracted from bacterial suspension are filtered and diluted, and the HD is found do emit low frequency em waves.
- (c) What is interesting is that emission stops when the medium gets in close contact with an infected individual. What could this mean?

In the TGD framework, this question can be reformulated. Suppose that the emission is analogous to biophoton emission and consists of dark (N -)photons, which have transformed to ordinary photons. Could the flux tubes of the representation of the micro-organism or of its DNA in HD reconnect with the infectant flux tubes of infected individual so that the radiation does cannot leak out anymore as ordinary photons?

- (d) It is possible to detect the em radiation of HIV DNA even when the RNA of virus has disappeared from blood. Could this mean that HIV DRNA remains in the organism?
- (e) Montagnier's group has also reported that it is possible to reconstruct DNA sequences from the EM signal produced by HD [I103, I102]. I have already discussed the findings these findings from the TGD view point in [L12, L15].

11.4.2 Water bridging dynamics of PCR chain reaction

This section discusses the article: " *Water Bridging Dynamics of Polymerase Chain Reaction in the Gauge Theory Paradigm of Quantum Fields*" of Montagnier *et al* [I104](<https://cutt.ly/yArqeJz>) from the TGD view point.

The basic goal is to understand the DNA-enzyme coupling in DNA polymerization. The polymerization process is a highly organized time-ordered sequence of steps with a precise spatial organization. Computer program is the first analog that pops up into mind. DNA polymerization and biocatalysis in general are extremely difficult to understand in a nothing-but-chemistry approach, which suggests a stochastic process in a sharp conflict with these features.

The proposal of authors in accordance with the vision of Fröhlich that quantized dipole electric fields make possible states which are known as Fröhlich condensates but can one argue bringing in quantum field theory is not enough. The coherence of living matter would naturally follow from quantum coherence in long scales but standard quantum theory fails to produce this: the value of Planck constant is simply too small.

The characteristics of the process fits nicely with the basic predictions of ZEO that quantum states are superpositions of space-time surfaces obeying not only determinism dynamics but being analogous to Bohr orbits. This together with hierarchy of Planck constants would also explain the long scale coherence and precise spatial organization.

The findings

Polymerize chain reaction (PCR) is a method of detecting the presence of DNA in a solution. The article reports findings about highly diluted viral or bacterial DNA in water. The solution contains also DNA polymerase (DNAP), which is thermostable up to 80 C and even above it albeit non-functional. This DNAP, briefly *Taq*, is associated with a heat tolerant strain *T. aquaticus*. *Taq* is used in PCR quite generally. The properties of *Taq* do not seem to be relevant for the findings.

- (a) Some viral or bacterial DNAs in a very highly diluted agitated solution (HD) ($10^{-6} - 10^{-10}$) emit electromagnetic radiation (EMS). In the ELF range 40-2000 Hz EMS is several orders of magnitudes more intense than elsewhere. The log-log plot of power is in this range linear and there are self-similar fluctuations regarded as a signature of coherent dynamics at microscopic level.
- (b) This radiation is recorded and the first dilutions show no signal. The recorded radiation pattern generates electric current creating a time dependent magnetic field in a sample containing only water and *Taq* and oligonucleotide primers.

It is assumed that coherent nano domains representing DNA are formed in water or cellular water. The signal would be read by *Taq* polymerase in presence of primers and XTPs, X= A,T,C,G. A polymerization of the viral or bacterial DNA is observed by PCR. In the TGD based model [K149] the term "remote replication of DNA" is used. It would seem that *Taq* pairs with coherent nanoscale domains representing DNA and induce a polymerization of ordinary DNA around it.

- (c) In the second experiment water is replaced with a flask of living cultured tumor cells or in vitro cell lines. DNA polymerization is observed by PCR also now. Cell growth is inhibited and cells die.

How do *Taq* and oligonucleotide primers find each other to make DNA amplification possible?

The proposal is that dipole electric fields define morphogenetic fields somehow representing DNA. These fields are treated in the gauge theory paradigm involving symmetry breaking and generation of Goldstone bosons generating long range correlations as collective modes. But can collective modes really represent detailed information about genetic codons? This is local information in nanometer scale requiring wavelengths of order nm meaning energy of order 10^3 eV for photons and considerably above the natural energy scale of few eV for molecular transitions.

TGD based model for the findings

The TGD explanation for the findings would go as follows.

- (a) The mechanism to be discussed works in both experiments. The relevant system would be the dark counterpart of DNAP (DDNAP), which would be modified so that it couples only with the DDNA transmitted to the system electromagnetically. In the first experiment DNAP would *Taq* and in the second experiment the DNAP associated with the cells of the sample.
- (b) The nanoscale domains would correspond to the remotely generated DDNA as flux tubes at which codons are realized as dark nucleon triplets [L141, L96, L108]. The resonance mechanism for the pairing of DDNA and dark DNA polymerase proteins (NDNAP) paired with DNAP proteins applied to DDNA-DDNAP pair could explain the findings in both cases. Dark 3N-nucleons as a representation of dark genes/proteins accompanying ordinary genes/proteins pair via dark 3N-resonance.
- (c) DDNAP would tune to the cyclotron energies and frequencies of electromagnetically transmitted DDNA by changing the radii of the dark magnetic flux tubes of DDNAP paired with DNAP. Dark 3N-resonance coupling would lead to the polymerization.

The general mechanism would be the same as in homeopathy and water memory [K58] in which MBs of water clusters tune their flux tubes to the cyclotron energy (and possibly also frequency -) spectrum of the invader molecules and in this manner form its low frequency representation.

- (d) This mechanism would be the fundamental mechanism of the immune system and of bio-catalysis.
 - i. U-shaped flux tubes would act as tentacles inspecting the environment for invader molecules and eliminate them by reconnection. Flux tubes would continually vary their thickness to vary the frequency scale of their siren's song and the invader molecule would be caught when a reconnection at resonance is formed.
 - ii. In bio-catalysis in which reconnections between U-shaped flux tubes to a pair of flux tubes in resonance would form bridges between reactants and catalyst and the reduction of h_{eff} would shorten the flux tubes and bring them close to each other. The energy liberated would help to get over the potential energy wall so that the reaction would proceed swiftly.
- (e) The magnetic flux tubes of the DNAP would change their thickness so that the cyclotron frequency spectrum of DNAP tunes to that of the DNAP of the EMS emitting system. There would be tuning of the frequency scale and perhaps also frequency ratios to some extent. DNAP would retune within few days and start to resonate with the frequency the spectrum of the DDNA representing the electromagnetic invader.
- (f) The tumor cells and in vitro cells would die because their DDNAP tunes to the DDNA of the invader and loses its tuning with the DDNA of the tumor/in vitro cells. What happens if non-tumor cells are used? If the healthy cells do not die, they could have an electromagnetic immune system preventing the modification of the cyclotron frequencies of the flux tubes of their DDNA. This immune system could explain why remote mental interactions between different organisms are very rare [K128].

11.5 DNA resonance code

The experimental findings represented in three articles by Savelev *et al* motivated this section. The articles are

- Savelev *et al.* "On The Existence of The DNA Resonance Code and Its Possible Mechanistic Connection to The Neural Code" [?] (<https://cutt.ly/KAe6B0d>).
- Savelev and Myakishev-Rempel "Possible traces of resonance signaling in the genome" [?] <https://cutt.ly/rArqd1A>
- Savelev *et al* How the biofield is created by DNA resonance [?] (<https://cutt.ly/EArqzSL>).

The motivating observation is that molecular gradients and neuronal signals are too imprecise if one wants to understand processes like DNA polymerization.

Gurwitch, Miller and Webb, Burlakov, Montagnier, Meyl, etc... introduced the notion of morphogenetic field, Miller and Webb assumed that the morphogenetic field is holographic and is generated by DNA.

The finding of Meyl that there is no dissipation involved with the morphogenetic field, suggests that quantum coherence in long scales is involved and that this coherence might induce the coherence of biomatter.

It is argued that if the morphogenetic field is generated as a dipole field by moving charge carriers, they should have a low mass and be isolated from the cellular water. Base pairs are hydrophobic and this forces the distances of the bases to be minimal whereas the charges of the phosphate tend to make DNA as straight as possible. This leads to a proposal that DNA strands or at least parts of them act as resonators producing the morphogenetic field, which could represent the genetic code as the findings of Montagnier *et al* suggest. It is proposed that the repeating parts of DNA which do not code for proteins and are usually identified as junk DNA could act as kind of quantum antennas.

11.5.1 Some findings of Burkalov and their TGD based explanation

There are several experimental findings supporting the presence of morphogenetic fields. Gurwitch and Benveniste who studied water memory belong to the pioneers of the field. Also biophotons, which are not discussed in the articles commented in this article, could closely relate to the morphogenetic field.

Burkalov studied fish embryos inside two quartz cuvettes above each other, 50 fish embryos in each cuvette in sealed quartz cuvettes. They are incubated for several days in a metal box lasting for several days. It was found that older embryos inhibit the development of younger embryos.

It was also found that a germanium mirror accelerates the development if a single cuvette is placed on it. Quartz retroreflector prism in turn represses the development and causes abnormalities. Retroreflector has the basic property that it reflects back by 180 degrees independently of the angle of incidence. Reflector reflects in this manner only if the incidence is normal.

Consider now a possible TGD based explanation for the findings of Burkalov.

- MB has an onion-like hierarchy of layers and would take the role of a morphogenetic field as a controller. Magnetic flux tubes would determine the morphology. Some higher layer of MB could send control commands through the genomic repeats which in turn would control the transcription and other basic processes. Alu repeats involve promoters.

The lowest level in MB hierarchy would correspond to DDNAs paired with DNAs? Same for other linear information molecules. Higher layers of MB could use genomic repeats as control knobs.

- The frequency scale for bioharmony changes with aging, and the first guess is that it slows down. Younger embryos have very sensitive MBs able to rapidly modify the flux

tube thickness and tune to the external source. Older embryos therefore induce a modification of the frequency scale of the dark flux tubes of younger embryos. Development slows down or stops because the resonance between DDNA and DNA is lost or does not conform with the biological evolutionary age for proteins.

- (c) In the experiments involving reflector, the dark photons leaking out as ordinary radiation are reflected and leave the system. In retroreflector the ordinary radiation returns back and causes the decoherence of dark N-photons: instead of dark N-photon ordinary photo is absorbed. Could retroreflection slow down the gradual scaling of frequency scale?

11.5.2 Electron and proton chains along DNA as sources of morphogenetic field?

The proposal is that electron and proton chains along the stack formed by base pairs serve as the source of the morphogenetic field. The proposed electron and proton chains are called HIDERS (Homologous If Decoded Elements, Repetitive).

- (a) Morphogenetic field is identified as electromagnetic dipole field assigned to DNA. Resonant oscillations of delocalized electron and proton chains in the base stack of DNA are proposed to serve as the source of the field.
- (b) Hydrophoby pushes bases together and phosphate charges make DNA maximally linear. This volume is insulated.
- (c) Base pairs of the double DNA strand (A-T, C-G) oscillate between tautomeric states with frequency in the MHz-THz range. G-C base pairs have three tautomeric states whereas A-T has 2 tautomeric states. There are also aromatic rings oscillating between aromatic and non-aromatic states. They are predominantly in non-aromatic states and one can ask whether the switching forth and back between these states has some role in biocontrol.
- (d) Aromatic rings are suggested to unite into a stack such that electrons are delocalized along this stack. There is evidence for pi electron chains along hydrophobic base stack associated with purine (A,G) stretches. There is also evidence that these stretches get longer during evolution and that they are conserved.

DNA charge transfer provides support for the electron chain concept. DNA acts as 1-D conductor and semiconductor and both electrons and holes act as charge carriers.

- (e) The proposal is that proton chains associated with the longitudinal hydrogen bonds, which is introduced as a new notion, exist. Both electron and proton chains would reside inside a linear double-helical crystal with insulation caused by hydrophoby. This suggests that the dissipation of energy for the chains is very low as the experimental findings about the morphogenetic field require.

Genomic repeats as a source of morphogenetic field?

Genomic repeats are introduced as a further key concept.

- (a) The starting point is the observation that only 1 % of the human genome corresponds to a coding genome. The non-coding is called junk DNA. 2 % of the genome is conserved and non-coding and must have some important function. The function of the rest 97 % is unknown. Introns, which are spliced from mRNA in the maturation of the final mRNA product belong to the non-coding part.

- (b) Genomic repeats associated with the intronic portions of the genome must have some important function. There are many kinds of repeats. The smallest repeating structure is a single nucleotide. Also 2-,3-,4-, and 5-nucleotide repeats called microsatellites are frequent. Telomeric and centromeric repeats. Telomeric and centromeric repeaters belong to the simplest repeaters. Typical telomeric repeat is 6 bases long GGGTTA. Human telomeres are around 2500 repeats long. The proposal is that they define fundamental resonators.

Purine (A,G) repeats are identified as the most important repeats. There is evidence that the lengths of purine chains increase during evolution and that they are conserved.

- (c) Alu repeats are about 300 bp long, appears in primates only, and has the highest number in the human genome. There are about 1.1 million copies of Alu. Alu is an interspersed repeater meaning that it does not repeat periodically but in a random manner. Alus are near genes and strongly bind to nucleosomes and often serve as a crystallization point for chromatin condensation. Alus coil around almost two nucleosomes. Alus are frequent and conserved in gene promoters, which suggests a possible regulatory role.

Alus code for an untranslated RNA so that they decompose to codons. The variations with an Alu sequence in a gene promoter correlate with the transcriptional activity of the gene. Alus are normally silent but are activated during cellular stress. The methylation pattern for Alus vary and this affects the RNA expression. It is not clear whether methylation affects the possible control role otherwise.

Alus are possessed only by primates and the proposal is that Alu makes us humans. Alus would receive the wave information of the morphogenetic field and convert it to bioinformation by controlling gene expression.

Some objections as a way to end up with the TGD based view

The work of Fröhlich [J76, I119, I135] [J76] has inspired the idea about the fundamental role of electric dipoles in biology (<https://cutt.ly/3AmIKQi>). Electric dipoles would give rise to Fröhlich condensates explain the coherence of biosystems which remains a mystery in standard quantum physics. No direct evidence for them have been found.

There are some objections against the fundamental role of electric dipoles and dipole radiation.

- (a) In contrast to magnetic moments, the electric dipole moments of elementary particles vanish to extreme accuracy so that electric dipoles should be associated with composite states such as atoms and molecules which are however heavy so that morphogenetic field would be generated by mass motion of DNA and require considerable metabolic energy feed.
- (b) The time scale of control dynamics should be slow as compared to the time scale of electric dipoles. For instance, DNA transcription involves time scale of order .1 second assignable to alpha rhythm. Cyclotron frequencies in the magnetic field of order Earth's magnetic field correspond to this time scale. It would seem that cyclotron radiation relates more naturally to the notion of a morphogenetic field. Here however the extremely small energy is the problem and led to the $h_{eff} = n \times h_0$, which later emerged from the number theoretic vision of TGD.
- (c) One can however consider a different realization of the electric dipole idea. Electrets populate biology, which suggests that nano-scopic and microscopic structures formed from dipole-like entities are crucial. Electret property implies a coupling between acoustic and electromagnetic degrees of freedom and is very probably crucial for hearing. Basically acoustic oscillation corresponds in TGD framework to oscillations of flux tubes connecting particles and if for charged particles forming a dipole this coupling becomes possible.

For instance, in the TGD vision cell membrane can be regarded as a (actually a generalized) Josephson junction and if dark matter hierarchy is accepted, Josephson frequency is given by ZeV/h_{eff} and is very small for large enough h_{eff} . One obtains the desired slow time scale and energy scale just above thermal energy. Also DNA and microtubules have longitudinal electric fields.

Comorosan effect [?, I65] means that there are 5 second and 10 second periods associated with molecules. They are not understood but the interpretation in terms of Josephson frequency of a polarized molecular bond is attractive [K145].

Magnetic dipoles at elementary particle and ion level and macroscopic electric dipolar structures like cell membrane, DNA strand and microtubule would play a fundamental role in the TGD inspired biology and the hierarchy of Planck constants would make the interaction between them possible.

It is quite possible that genuine quantum coherence is realized only at the level of MB and the coherence of biomatter is induced by MB and is not genuine quantum coherence. This would solve the problem due to the fact that the standard value of Planck constant does not allow quantum coherence in long scales.

TGD view about the role of genomic repeats

The TGD view about how dark information molecules DDNA, DRNA, DtrRNA, DAA couple with each other and with ordinary information molecules has been discussed. One would have a slaving hierarchy with levels labelled by h_{eff} controlling each other by energy resonance coupling using dark variants of genes as dark 3N-photons analogous to BE condensates.

They would have energies in biophoton range (visible and UV), very probably also in IR range since metabolic energy quantum around .5 eV must be included, and possibly also in microwave photon range and the energy scale of about .2 eV defined by membrane potential.

These transitions would control chemical reactions, induce conformational changes of biomolecules, etc...

The motor actions of MB would naturally induce conformational changes of molecules and also larger objects. The geometric degrees of MB would be behind morphogenesis. Biological growth could quite concretely correspond to the growth of MB meaning increase of h_{eff} of the highest level present in the hierarchy.

How does this view relate to the proposal that repeating DNA sequences serve as antennas, resonators and circuits?

- (a) HIDERS could be present. Electron and proton spins could be important and DDNA could induce spin magnetization in turn generating magnetic fields inside DNA inducing currents in aromatic rings.

An interesting question is whether these currents create a magnetization summing up to zero with spin magnetization: one would have perfect diamagnet. Does this mean electronic super-conductivity inside DNA. I have indeed proposed this earlier. The idea that HIDERS serve as electric dipole oscillators does not however look attractive.

- (b) Repeating DNA sequences, in particular Alus, must have an important role in communication to and control by higher layers of MB. The presence of higher layers of MB conforms with the fact that Alus are not present in non-primates. Also the connection with epigenesis is suggestive.

Could Alus serve as control knobs or could they send sensory information to MB and therefore play the same role as cell membrane? Could electric dipolar structure play quite generally the role as generators of sensory input and could MB respond by sending cyclotron radiation as a response?

Consider now in more detail the possible role of Alus in the TGD framework.

- (a) DNA and also Alus carry a longitudinal electric field making it a long dipole. Also codons act as dipoles with dipole moment depending on the codon. Could the idea that the entire Alu acts as a long Josephson junction make sense? This would not allow information transfer using genetic code.
- (b) Could codons act as Josephson junctions with Josephson energy $Ze\Delta V$ depending on the codon. Could these Josephson junctions form a 3N-Josephson junction generating coherently dark Josephson 3N-photons as sensory input to MB. The modulation of Josephson current would code for sensory input. This would induce a sequence of resonance pulses at the layer of NB producing a feed back sending sensory data to MB, which could induce control actions, such as DNA transcription.
- (c) From the length of Alu of order $L \sim 10^{-7}$ meters (300 bps/100 codons) the estimate for the Coulomb energy of electro associated with the entire length is about Z^2e^2/L , for opposite charges at the ends of Alu if it has charges $\pm Z$ at its ends. This corresponds to energy of order few eV and is in the biophoton energy range. This would conform with the energy scale of dark cyclotron photons.

DDNA could serve as the nearest boss of DNA. Also higher levels in the hierarchy of MB layers would realize dark genetic code if the icosahedral tessellation at H^3 defines a universal realization of genetic code.

Since genetic code would be used in the communications, the sensory signal would go to MB with dark codons similar to Alu.

- (d) Somehow a control response should be generated as a response. Suppose that Alus, and perhaps entire DNA, is magnetized. This could be made possible by possible spin polarization of electron chains and/or rotating currents in aromatic rings. Could MB realize control commands by using dark cyclotron 3N-photons absorbed by Alu?

A universal standard control knob property Alu, or of a repeating unit in general, would allow minimal complexity of the nucleotide content. The flux tube connections would allow targeted control commands such as activation of promoters of gene transcription. Note that Alus also code for RNAs having some function but are most of the time silent and are used only in emergency situations (cellular stress).

There is an interesting experimental finding, which could be seen as a support for the presence of dark UV photons at magnetic flux tubes.

- (a) The irradiation of cultured mouse fibroblasts at low power millimeter waves at certain wavelengths protects DNA against damaging effects of UV radiations. What comes to mind is the shielding of the biosphere by the magnetic field of Earth: the cosmic radiation sticks to the flux tubes.
- (b) Could UV radiation be caught by MB flux tubes with large h_{eff} and transform to dark radiation with much longer wavelength? Could some fraction of the millimeter irradiation transform to dark photons with UV energies? Could the flux tubes of MB tune to millimeter radiation so that they become sensitive to it? Could a BE condensate of photons with energy in UV range emerge and serve as induce the BE condensation of ordinary UV photons so that they would be defused?

11.5.3 Is DNA magnetic?

The article also discusses the possible magnetism associated with DNA. DNA strands seem to behave like pairs of magnets. Ring currents could cause the magnetization but their presence requires an external magnetic field inducing magnetization.

The problem is that in an external magnetic field DNA becomes orthogonal to it and no magnetization is generated. The source of the external magnetic field must stay parallel to DNA which is impossible in standard view about DNA.

The proposal is that the ring currents are induced by some enzyme in the presence of ATP. There is also the question whether the magnetization is static or oscillatory.

The TGD view of DNA as a magnetic system would be following.

- (a) DNA strands seem to behave like pairs of magnets. Ring currents could generate magnetization. A strong enough magnetic field parallel to strands is needed to induce the magnetization. The DDNA associated with dark monopole flux tubes (no current needed to create the magnetic field), necessarily parallel to DNA, would induce the magnetization of DNA. Connection with DDNA in icosahedral picture emerges.
- (b) How DDNA could couple with the DNA magnetization? The magnetic field is strong and from flux quantization it would be of order 100 Teslas. Cyclotron frequency scales are totally different. $f_c(e) \sim 3 \times 10^{11}$ Hz. For $\hbar_{eff} = \hbar$, the cyclotron energy is of order 3 meV and below thermal energy. Could DNA interior be thermally insulated from the environment. $\hbar_{eff} = n\hbar$, $n \sim 10^3$ would give a few eV scale for the cyclotron frequencies.
- (c) Large \hbar_{eff} cyclotron 3N-photon transforms to a single ordinary photon with much larger energy and is absorbed in ordinary cyclotron transition by DNA magnet and induces motor action of DNA.
- (d) Control communication from higher layers of MB could take place via repeats whereas for coding regions only the lowest layers of MB, such as DDNA would be involved. Alu regions as control knobs in gene expression controlled by MB. All layers of MB could realize dark genetic code but in a different scale proportional to \hbar_{eff} .

11.5.4 Dark 3N-resonances and quantum teleportation

Could the communication by 3N-resonances relate to quantum teleportation? This is possible but requires modifying the previous assumption that the states of dark proton sequences are fixed and correspond to those of ordinary genes with which they are in energy resonance when communicating. One must loosen this assumption.

- (a) Give up the assumption that cyclotron states of the dark 3N-proton are always the same and correspond to a gene. Assume that in some time scale, perhaps of order cyclotron time, dark proton sequences representing genes decay to the ground state configuration defining an analog of ferromagnet.
- (b) Assume that some excited dark 3N-photon states, dark gene states, can be in energy resonance with ordinary genes, most naturally the nearest one if dark DNA strands are parallel to an ordinary DNA strand. Even this assumption might be unnecessarily strong. Dark 3N-proton would interact with its ordinary counterpart by energy resonance only when it corresponds to the dark variant of the gene.

Same applies to dark genes in general. Only identical dark genes can have resonance interaction. This applies also to the level of other fundamental biomolecules RNA, tRNA and amino acids.

- (c) What is this interaction in its simplest form? Suppose dark 3N-proton is in an excited state and thus defines a dark gene. Suppose that it decays by SFR to the ground state (magnetization) by emitting dark 3N-photon. If this 3N photon is absorbed in SFR by a dark proton sequence originally in ferromagnetic state, it excites by resonance the same gene. The transfer of entanglement takes place.

This is nothing but quantum teleportation but without Alice, doing Bell measurements and sending the resulting bit sequences to Bob, performing the reversals of Bell measurements to rebuild the entanglement.

This suggests a modification of the earlier picture of the relation between dark and chemical genetic code and the function of dark genetic code.

- (a) Dark DNA (DDNA) strand is dynamical and has the ordinary DNA strand associated with it and dark gene state can be in resonant interaction with ordinary gene only when it corresponds to the ordinary gene. This applies also to DRNA, DtRNA and DAA (AA is for amino acids).

This would allow DDNA, DRNA, DtRNA and DAA to perform all kinds of information processing such as TQC by applying dark-dark resonance in quantum communications. The control of fundamental biomolecules by their dark counterparts by energy resonance would be only one particular function.

- (b) One can also allow superpositions of the dark genes representing 6-qubit units. A generalization of quantum computation so that it would use 6-qubits units instead of a single qubit as a unit, is highly suggestive.
- (c) Genetic code could be interpreted as an error code in which dark proteins correspond to logical 6-qubits and the DNA codons coding for the protein correspond to the physical qubits associated with the logical qubit.
- (d) The teleportation mechanism could make possible remote replication and remote transcription of DNA by sending the information about ordinary DNA strand to corresponding dark DNA strand by energy resonance. After that, the information would be teleported to a DNA strand in a ferromagnetic ground state at the receiver. After this, ordinary replication or transcription, which would also use the resonance mechanism, would take place.

Could there be a connection with bioharmony as a model of harmony providing also a model of genetic code [L22, ?, L108]?

- (a) In the icosahedron model, the orbit of the face of icosahedron under the group $Z_6, Z_4, Z_{2,rot}$ or $Z_{2,refl}$ would correspond to single physical 6-qubit represented as dark protein.

This representation of the logical qubit would be geometric: orbit rather than sub-space of a state space. One could however assign to this kind of orbit a state space as wave functions defined at the orbit. This representation of $Z_6, Z_4, Z_{2,rot}$ or $Z_{2,refl}$ would correspond to a set of 6-qubits, which replaces a single 6-qubit.

- (b) The TGD proposal for TQC [L134, L140] is that the irreps of Galois groups could replace qubits as analogs of anyons. Could these orbits correspond to irreps of Galois groups or their subgroups, say isotropy groups of roots?

Another option is the finite subgroups G of quaternionic automorphisms, whose McKay graphs, characterizing the tensor products of irreps of G with the canonical 2-D irrep, give rise to extended Dynkin diagrams [L132]. What puts bells ringing is that $Z_6, Z_4, Z_{2,rot}$ or $Z_{2,refl}$ are subgroups of the icosahedral group, which corresponds to the Dynkin diagram of E_8 .

These alternatives need not be mutually exclusive. I have proposed that Galois groups could act as the Weyl groups of extended ADE Dynkin diagrams given by McKay graphs of finite subgroups of $SU(2)$ interpreted as the covering group for the automorphism group of octonions. The Galois group and its subgroup would define a cognitive representation for the subgroup of the covering group of quaternion automorphisms.

The communications by the modulation of frequency scale 3N-Josephson frequency scale are still possible.

- (a) The 3N-resonance occurs when the receiver 3N-proton is in ferromagnetic ground state and the 3N-Josephson frequency corresponds to 3N-cyclotron frequency. If the time scale for the return to the ferromagnetic state is considerably shorter than the time scale of modulations, a sequence of resonance pulses results and codes for the frequency

modulation as an analog of nerve pulse pattern. This communication can lead to communication if the ordinary gene accompanying the excited dark gene is in energy resonance with it.

- (b) It must be noticed that the communications by dark $3N$ -resonances are not possible in standard physics and are made possible only by Galois confinement and h_{eff} hierarchy. In standard physics only single photon fermion interactions would be present and would be relatively weak. In quantum computation, this suggests the possibility of quantum coherent manipulation of N -qubit states by dark N -photons instead of qubit-wise manipulations prone to errors and destroying the coherence. There is evidence for N -photon states with these properties [D14, D14]: for the TGD inspired comments see [L114].

Chapter 12

TGD view of Michael Levin's work

12.1 Introduction

This article was inspired by the work of Michael Levin's group in biology. I have already earlier (2014) commented the work of Levin [I153, I154, ?] in the article [L23]. To my view, these discoveries profoundly modify the views of the role of genes and lead to a completely new vision about morphogenesis about which genetics cannot tell much.

The amazing discoveries by Michael Levin and others related to morphogenesis (such as the discovery of xenobots as synthetic life forms) could lead to the correct track not only in biology and neuroscience but also in attempts to define and construct AI and artificial life.

The articles [I155, I157, I149, I60, I137, I156] provide a good view of the vision of Levin. Interested readers can listen the interviews and talks of Levin in web.

I started with the interview of Michael Levin at <https://youtu.be/XheAMrS8Q1> with title "The electrical blueprints that orchestrate life". The talk "Plasticity without genetic change: bioelectric embryos & synthetic proto-organisms" (<https://www.youtube.com/watch?v=5ChRM4CEWyg>) gives a summary of the role of bioelectricity in embryos and about the synthesis of artificial organisms known as xenobots.

The talk "Understanding the Collective Intelligence of Cells: bioelectrical navigation of anatomical morphospace" at (<https://www.youtube.com/watch?v=jLiHLDr0TW8>) provides a view of morphogenesis as a navigation in morphospace towards the final morphology as a goal represented as a memory.

The talk of Josh Bongard titled "A xither of xenobots: demolishing dichotomous thinking with synthetic proto-organisms" (<https://www.youtube.com/watch?v=7EA2AqS05tQ>) discusses the implications of the findings for fields like AI. The talk is about brain/body -, genotype/phenotype -, and tape/machine dichotomies, which have made a real progress in orthodox AI difficult, if not impossible. The article [I137] discusses the same topics.

The approach of Michael Levin does not mention quantum biology at all. At least from the perspective provided by the TGD inspired view of quantum physics and quantum biology, the findings are however extremely inspiring. In the sequel, I will discuss these findings and the theoretical vision inspired by them, and also the interpretation of findings in the framework of TGD inspired theory of consciousness and of quantum biology. These findings provide crucially important bits of data for a further development of the already existing TGD view of morphogenesis [L23, L139, L129, L125]. Also the interpretation of the zero energy ontology (ZEO) [L89] becomes more precise.

12.1.1 About the basic vision and experimental findings of Michael Levin

The basic challenge is to understand how organisms evolve from embryo to their final shape. Genetics applies at the level of a single cell and does not offer clues of how genes might determine the shape and size of the organism. Therefore the dogma that genotype determines phenotype has remained an unproven hypothesis. Already the emergence of epigenetics has made clear that genes are not enough: the same genome has very many transcriptions, which can vary in a very rapid time scale for a given organism. The work of Levin's group has shown that the correspondence between genotype and phenotype is even more flexible: one can even create new life forms using a given genome (zenobots).

Does bioelectricity code for morphogenesis?

The underlying idea is that the dynamics of the brain as a collective of neurons has evolved from the morphogenesis of cell groups. Instead of a communication using nerve pulses patterns, the communications use the distribution of membrane potentials (hyperpolarization and depolarization). Static gap junctions in turn take the role of much more dynamic synaptic contacts.

- (a) Dynamical patterns of membrane voltages assignable to cell membranes, which are determined by the voltages assignable to voltage gated ion channels and pumps, connectivity of cell groups determined by the distribution of gap junctions, plus long range potential gradients controllable by the patterns of membrane potentials, seem to act as a new control level which also controls the epigenetic level. The membrane voltage pattern and distribution of gap junctions are controlled in the experiments of Levin's group using biochemical tools.
- (b) The potential gradients in the scale of the organism or organ associated with the embryo in turn determine the morphogenetic goal as an analogue of memory in the same way as voltage gradients correlate with the state of the brain.
- (c) Electric signals as oscillation patterns of membrane potentials between cells mediated via gap junctions are proposed to actualize an analog of a computer program. This signalling is also referred to as conversation, which would be something less deterministic. The program would code the destiny of the cell group.
- (d) Self-organization in some sense is involved. Dissipation takes care that self-organization leads to a very few final states from a larger number of initial states. It is not however clear whether biological self-organization can be described by the standard picture in which self-organizing dissipates incoming energy and ends up to a thermal non-equilibrium. Related question concerns homeostasis: how is the system able to stay near a critical state, which is by definition unstable? Here self-organized criticality is a suggestive notion and to my best understanding not very well-defined.

Some astonishing findings

Manipulation of gap junction distributions and very specific ion channels has led to a handful of very astonishing findings providing deep insights of the basic mechanism of morphogenesis.

- (a) Planarians are animals which create offspring by replicating. They can be split even to 200 pieces such that every piece develops to a full-grown planarian. One might say that planarians do not experience aging at all. Long length scale electrical gradient rather than genome determines the positions of head and tail. Knowing also when to stop the growth is very important. How this is realized is not understood. Does the morphology of an adult planarian have a representation serving as a template in growth?

It is possible to manipulate the ion channels and gap junctions such that electrical field configuration changes and the split planarian develops to two planarians having two heads. This feature is preserved in further splittings of the planaria.

Also the memories of the parent planarian (defined as behavioral patterns) are inherited by the daughter planarians. The development of larva to a butterfly is a second example. The phenotype and also the brain of the larva are dramatically changed in the transition but the memories of the larva are preserved. This suggests that the memories are not presented at the level of the brain.

- (b) The gut cells of frogs, whose membrane potentials and gap junctions have been appropriately manipulated to give rise to long range electric gradients, can generate a functioning ectopic eye located outside the head. Also other organs, even those usually not possessed by frog, can be generated in this way.
- (c) In Picasso frogs the embryo is mixed so that various parts of the embryo are in the wrong places. The embryo however develops into a normal frog. Therefore morphogenesis cannot be a hardwired set of movements. There is minimization of error and goal directed behavior.

Computer scientists would talk of a computation determining the large scale anatomy, with computation interpreted as a search of the goal configuration in morphospace and represented as a stable memory. Conscious theorists would talk of a goal directed behavior as intentional behavior.

- (d) Xenobots are a completely novel life form evolving from appropriately manipulated frog embryos involving removal of a fraction of cells. Genetically unaltered cells coalesce and are liberated from the rest of the body. Novel bodies are different from tadpoles and epigenesis is different. For instance, cilia have a different function. In the frog, they transfer the mucus whereas xenobot uses the cilia for swimming.

12.1.2 Giving up genetic determinism

The basic belief is that genotype determines the phenotype. Only adaptations can change the phenotype. Programming by machine code serves as a metaphor. The computer itself is modified in the programming. The emergence of computer languages meant a revolution and information science was born. There was no need to modify the hardware anymore. Computer programs, represented as input signals, defined the computation. Only the simplest functions are realized as programs at the level of hardware and their functional composition gives rise to programs in accordance with the Turing paradigm.

One can say that most of the recent biology studies only the machine code level. Genes code for the basic building bricks (proteins). Biological systems would be like computers determined by the genetic code. Genetic determinism reflects this belief. This approach leaves open how the behaviors analogous to running computer programs emerge. Machine code metaphor would suggest they are determined completely by the hardware, genes.

The revolutionary idea is that there exists an analog of higher level computer languages based on electric fields. Bio-electric programs would correspond to electrical signalling. Morphology would be based on patterns of electric voltages assignable to cell membranes determining potential gradients in longer scales. For the early embryo these gradients would code for the morphology.

The examples mentioned in the introduction allow us to deduce conclusions of this programming.

- (a) The morphology of an adult planarian is coded by the long scale electric fields of the embryo. Also the memories interpreted as behaviors are inherited in the replication of planarians by splitting. This means that the morphogenesis is goal directed and goal corresponds to a stable memory.

If the long range potential pattern of adult planarian is manipulated to produce 2-headed planarian after the splitting, the planarian is not affected. Therefore one can say that the memory of the electric field pattern matters but that in the splitting the memory is replaced by a new one. Also the descendants of split planarians have two heads so the memories are inherited in splitting.

- (b) The example of Picasso frog tells that even dramatic perturbations are not able to prevent the development towards a correct goal. Goal is indeed a stable memory coded by the electric state of an early embryo and the system is able to make error corrections.
- (c) The gut cells or frogs, when appropriately manipulated to modify the connectivity determined by gap junctions and the long range electric fields can develop to ectopic eye. Also other organs can be generated in this way. Even organs not usually possessed by planarians, such as fish fins, can be generated. Xenobots are novel life forms with the same genome as the frog.

These findings imply that the memory telling the goal can be rewritten and does not depend on gene expression. The same genome corresponds to the entire morphospace consisting of different organisms with different functions. Epigenetic level is however differently realized.

These findings are consistent with the proposal that goal is represented as a memory which is characterized by long-term stability, lability (rewritability), latency (conditional recall: the 2-headed planaria is generated only if the planarian is gut first), and discrete set of possible outcomes.

This inspires the computational hypothesis. Goal is computed. Electric signalling and classical long range potential gradients define an analog of genetic code and one can wonder whether some kind of morphic code based on the grading of the membrane potential exists. Difficult questions relate to the realization of the memory. How it can be stable if the organism itself is evolving. Some kind of time travel would be required for memory recall. Is it a conscious memory?

12.1.3 Xenobots challenge the dichotomous thinking in biology and AI

The talk of Josh Bongard having title "A xither of xenobots: demolishing dichotomous thinking with synthetic proto-organisms" (<https://www.youtube.com/watch?v=7EA2AqS05tQ>) discusses the implications of the findings of Levin's group for fields like AI. The topic of the talk are brain/body -, genotype/phenotype -, and tape/machine dichotomies, which, according to Bongard, have made a real progress in orthodox AI difficult, if not impossible.

- (a) Brain/body dichotomy states that the brain tells the body how to move. In this picture, the body is a dead robot, hardware, and the conscious brain is the central intelligence, the software, which determines how the body moves. This view has dominated the view about AI. Although this view is plagued by several paradoxes due to the fact that nerve pulse transmission is quite too slow to realize the multiple feedback needed to actualize the commands of the brain, it still dominates the thinking.

The talk illustrates the basic failure of robotics by videos of falling robots. This illustrates the basic difference between robots and living matter. Humans do not fall down although they are about to fall down all the time. This is because of homeostasis. Living matter is a critical system which by some mechanism is able to remain near the criticality. Robots are not such systems and they fall down.

Biology suggests how to make this view more realistic by assuming that both the brain, software and the hardware can adapt. For rigid robots only the brain adapts. The talk describes smooth robots whose shape can vary. The challenge is to have a moving robot and a genetic algorithm indeed allows to find brain/body adaptation

strategies. The genetic algorithm indeed discovers unexpected strategy in a situation making movement possible. Brain actually adapts very little for the model considered.

- (b) Genotype/phenotype dichotomy more or less equivalent with genetic determinism states that genotype determines phenotype. Epigenesis means the failure of the strictest form of this dichotomy. Xenobots mean much more dramatic failure. Same genome can give rise to different organisms.

AI has played an important role in the development of the Xenobots and a simple in silico model of the xenobot consisting of skin tissue and muscle tissue is discussed. In this model skin serves receive impulses from random actions of motor parts and are able to generate coherent motion. How this happens looks like a mystery. The mystery is much deeper: how selfish cells having only personal goals are able to transform to unselfish parts of an organism. This remains one of the deepest challenges of biology and the notion of emergence remains only a magic word without actual content.

- (c) Tape/machine dichotomy is central in computer science. Turing machine serves a mathematical model of computer. Tape would represent the program and the machine would produce from the input tape the output bubble. Self-replication machines are Turing machines able to replicate. The talk represents a simple model for von Neumann self-replicator, which consists of 4 parts A,B,C, and D representing the tape. A makes a copy of A+B+C and B then makes the copy of D and combines A+B+C and D together. This kind of self-replication is called kinematic self-replication.

In living matter this dichotomy is far from obvious although the notions of input as a generalized sensory percept and output as motor action make sense. In living matter the self-replication is very different and takes place by growing. There is no obvious identification of tape and machine.

Xenobots represent a biological actualization of a kinematic self-replication. Few generations of xenobots are possible. Genetic algorithm has been used to develop a simulation of self-replicating xenobots.

12.1.4 Brief comparison of Levin's views with the TGD view

Despite very different starting points, there are many similarities between Levin's views and TGD view.

- (a) Levin emphasizes the importance of cognition and also introduces the notion of self. Levin also talks of collective intelligence (swarm intelligence) and cognition and argues that all intelligence is basically collective intelligence.

TGD inspired quantum theory of consciousness predicts self hierarchy. In the TGD framework, number theoretic physics involving p-adic and adelic physics provides a mathematical framework for the description of cognition. One can say that number theory becomes part of physics. $M^8 - H$ duality would actualize the duality between the view about physics as geometry and physics as number theory.

One of the predictions is hierarchy of Planck constants identifiable as dimensions of algebraic extensions of rationals assignable to polynomials of real argument, which define space-time surfaces by $M^8 - H$ duality. This number theoretic holography involves almost deterministic holography at space-time level implying in biology an almost exact structure-function duality. Once one knows the 3-D surface, the 4-D space-time surface is almost uniquely determined as an analogue of Bohr orbit.

Number theoretic vision leads also to a universal mechanism for the formation of bound states, which would also describe the formation of quantum coherent units from parts, such as selfish cells.

- (b) The experiments of Levin's group demonstrate the failure of genetic determinism and genetic reductionism. For a given genome one can have a large number of very

different phenotypes involving different epigenomes. Genes would be only a hardware or lowest level of biological scale hierarchy and higher levels would control the lower levels rather than being determined by the gene level. Examples are genetic level, transcriptional level (epigenesis), morphogenetic level, physiological level, neurological level, and even higher levels. Multiscale competency is the term used by Levin. This means self-organization and slaving hierarchies.

In TGD these hierarchies correspond to fractal hierarchies of space-time sheets (MBs and EBs), p-adic length scale hierarchies, hierarchy of effective Planck constants labelling dark phases of ordinary matter, various algebraic hierarchies for symmetry algebras associated with TGD, to the hierarchies of inclusions of extensions of rationals, to the hierarchies of hyperfinite factors of type II_1 , and self hierarchies as hierarchies of conscious entities, selves.

- (c) Levin proposes electric coding of morphogenesis based on membrane resting potentials and that gap junctions connecting cells to each other give rise to connected morphogenetic units. For instance, cancer cell population would disconnect from the population. Furthermore electric signalling between cells based on membrane oscillations would be essential for morphogenesis.

TGD suggests that ordinary genetic code is only a special case. The genetic code is universal and there is a hierarchy of realization of genetic code. One fundamental realization of the genetic code would be in terms of so-called icoso-tetrahedral tessellation of H^3 [L108] and it would induce various realizations at the space-time level. Dark genes would provide 1-D realization and cell membranes might provide 2-D realization of the genetic code and even 3-D realizations can be considered.

Realizations of genetic code in terms of dark proton sequences with codon realized as dark proton triplet and dark photon sequences with codon realized as dark photon triplet are predicted.

In TGD, cell membranes correspond to electric bodies (EBs) and the proposal is that they act as Josephson junction communicating with the magnetic body (MB) using dark Josephson radiation and a cyclotron resonance mechanism transforming frequency modulated Josephson radiation to a sequence of pulses. Besides ordinary nerve pulse patterns, patterns of pulses in mV scale assignable to gap junction connected cell groups are predicted [L129] inspired by the experimental work of Prakash et al [I165, I163, I164] and Adamatsky [I52] and the TGD view of quantum gravitation [L125] predicting that quantum gravitational coherence is possible in arbitrarily long scales and is especially important in quantum biology.

- (d) The notion of morphospace corresponds in the TGD framework to the "world of classical worlds" (WCW) [K102] [L116, L142], which in the number theoretic vision has unique number theoretic discretization using appropriate extension of rationals.
- (e) In TGD, the notion of cognitive light-cone introduced by Levin corresponds to causal diamond (CD) [L89, L124] [K146], which is the basic notion in zero energy ontology (ZEO) providing a new ontology of quantum theory solving the basic paradox of quantum measurement theory. CDs form a fractal hierarchy.

Consider now the basic differences.

The basic difference is that Levin does not mention quantum theory at all. In the TGD framework, quantum theory is based on ZEO [K146] rather than the standard ontology of quantum mechanics, which relies on the identification of subjective time and geometric time of physicists. ZEO has rather non-trivial implications such as the prediction that in the ordinary state function reductions (SFRs) the arrow of time changes. These implications are crucial for understanding consciousness and biological self-organization. The views of free will and consciousness are different. Levin suggests what he calls a technological approach to Mind [I156]. The engineering based approach is proposed to lead to the notion of self, to explain cognition, and also even free

will as an illusion, and perhaps even consciousness. Self would be determined by the morphogenetic or some other goal, and would be in principle an experimentally testable notion. Levin assumes that cognition is universal and appears in all scales. Also in TGD cognition is fundamental and number theoretical physics (adelic physics) [L55, L56] is needed to describe the mathematical correlates of cognition. This leads to the view the physics as geometry and physics as number theory are complementary descriptions of physics [L90, L91, L142, L136] The ZEO based quantum measurement theory extends to a theory of consciousness. In the TGD framework, Self as it is identified by Levin, would correspond to the unchanging part of self, kind of "soul". Self is predicted to also have a changing part determined by the generalized sensory input and motor actions. The unchanging part of self would by holography serve as a memory dictating the goal of the evolution of self, in particular in morphogenesis.

Note: I give the references to the articles related to TGD, which appear at my homepage. The articles have been published also in the journals founded by Huping Hu (PSTJ, JCER, and DNADJ) and the list of the published articles can be found at my homepage (<https://www.tgdtheory.fi/tgdmaterials/curri.html>). The reason is that the articles at homepage are updated versions of original ones.

12.2 Levin's vision

In the following I try to summarize Levin's view of cognition and the big vision about implications of the new view of morphogenesis. The articles [I155, I157, I149, I60, I137, I156] provide a good view of the vision of Levin. The interviews and talks of Levin provide the best way to get a view of Levin's vision and the following only tries to summarize the most important points. The following interviews and talks provide a good overall view of Levin's work.

- (b) The electrical blueprints that orchestrate life (<https://youtu.be/XheAMrS8Q1c>)
 - Plasticity without genetic change: bioelectric embryos & synthetic proto-organisms (<https://www.youtube.com/watch?v=5ChRM4CEWyg>)
 - Understanding the Collective Intelligence of Cells: bioelectrical navigation of anatomical morphospace (<https://www.youtube.com/watch?v=jLiHLDr0TW8>)
 - Biology, Life, Aliens, Evolution, Embryogenesis & Xenobots (<https://www.youtube.com/watch?v=p3lsYlod50U>)

12.2.1 Technological approach to Mind

Levin proposes what he calls a technological approach to mind [I156]. Levin suggests an active engineering approach in which new structures are constructed and studied instead of a passive study of existing structures.

- (a) Levin suggests definitions for the notions of cognition, intelligence [I157, I149] and of self [I155]. It remains unclear to me whether cognition is assumed to involve consciousness.
 - i. There would be no privileged substrate of cognition. This might be taken to mean that cognition is something universal. This also suggests panpsychism.
 - ii. Intelligence is identified as the ability to solve problems in abstract spaces. The abstract spaces correspond to spaces of possible goals of the system in various scales and form a hierarchy. Problem solving means achieving a goal in the

space considered. The same goal achieved by different means: this would be the basic characteristic of intelligence.

Ordinary 3-space, morphospace and physiological represent basic examples of spaces. One can also talk of genetic and transcriptional spaces. The goal space at a given level can "bend" the space at the lower level so that the agents at the lower level start to collaborate instead of behaving in a selfish manner. In organisms, selfish genes become unselfish. In cancer just the opposite happens and means that the cancer cells as a subsystem quite concretely separate from the system.

- iii. Somewhat cryptically, the notion of self is identified as boundaries of goals that the system is capable of pursuing. More concretely, one might also say that the developmental goal of the organ or organism assigns self to it.

- (b) Developmental bioelectricity is another key notion. It is identified as a phylogenetic precursor of brain dynamics, a physiological medium for the software of life, and a medium of the cognition of morphogenetic swarm intelligence of cells. All intelligence is basically collective intelligence in which the subsystems start to collaborate to reach the collective goal.

- (c) Evolution would be greatly potentiated by multi-scale competency architecture [I60]. Evolutionary step would not be finding a solution to a problem but building a new kind of machine solving more complex problems. Increase of the scale and emergence of a new evolutionary level would be in question.

Selection by evolutionary pressures and random mutations drive the evolution in the Darwinian view. Levin expresses his view by saying: "where the goals come from, if not from selection?". One can of course ask whether the increase of complexity closely related to intelligence is a basic evolutionary goal of the Universe. This view seems to be in conflict with the second law however.

12.2.2 Levin's view of cognition

Multiscale competency architecture

Multiscale competency [I60] architecture is a key notion used by Levin.

- (a) Evolution uses multi-scale competency architecture to evolve machines that solve problems. The meaning of machine is however different from that in the recent technology [I137]. One could translate "multi-scale competency architecture" to a fractal slaving hierarchy in which higher levels whose dynamics is in longer spatial and length scales interact with lower levels and receive information from these levels and control them.

Scaling is a key aspect of evolution. Evolution step means the emergence of a system characterized by larger spatial and temporal scales of coherence and of higher complexity and consisting of the already evolved systems, which start to co-operate. The spans of memory and anticipation increase.

- (b) DNA specifies cellular hardware but is controlled by agential materials inducing different epigenetic patterns.
- (c) Dynamics is robust due to anatomical homeostasis. Morphogenesis can be seen as an intelligent behavior of a cellular collective solving problems in anatomical morphospace. Computationalist would say that problem solving reduces to a search in the morphospace in order to reach a goal.

- (d) The cognitive glue that harnesses cells towards large scale outcomes ("bends" the lower levels to collaborate) is developmental bioelectricity. Goals are represented by long scale electric patterns generated in the embryonic stage and are identifiable as pattern memories utilized by collective intelligence of the organ. The experimental work of Levin et al makes it possible to read and write pattern memories.

Collective intelligence of cells

<https://www.youtube.com/watch?v=jLiHLDrOTW8>

Usually one distinguishes between centralized intelligence (brain would be the basic example) and collective/distributed/swarm intelligence. Levin proposes that all intelligence is collective intelligence.

The proposed multiscale competency [I60] in which higher level "bends" lower levels to co-operate, could be translated as a slaving hierarchy involving "bosses". One can also speak of a nested cognition.

There is a high multiscale competency already at the level of a single cell and in this case the smaller subunits are subsystems of the cell down to the level of genes. Single cell morphology and behavior are indeed very complex. The cell can detect bodies in its environment by generating vibrations which are reflected from objects. Kind of sonar is in question and allows us to build a map of the environment. The cell is able to reach the desired targets of the environment using this information.

Levin lists the following key aspects of collective intelligence.

- (a) Navigation in morphospace towards the goal and multiscale competency architecture (slaving hierarchy) makes this possible. Higher level morphospaces "bend" the lower level morphospaces forcing them to collaborate.
- (b) Goal-directedness involves recognizing, building, and controlling and communicating with agents in possibly unconventional embodiments (non-standard phenotypes). Self is defined as a cognitive boundary identified as the goal of the system.
- (c) Anatomical control reflects the collective intelligence of cells navigating in the morphospace. Bioelectric networks and their proto-cognitive medium (ancestor of brain function) → impact on biomedicine. The term "proto-cognitive" suggests that ordinary cells are not assumed to cognize. The goal of an organ or organism is coded by the electric field patterns during early embryo stage and can be regarded as a memory.
- (d) Synthetic bioengineering as a construction of new bodies and new minds corresponds to the active, engineering aspect of the approach. What is new and racial is that the novel organism does the job itself when the goal is given.

The novel life forms have no evolution behind them and their possibility suggests that same genomes can give rise to widely different organisms and that also different life forms can give rise to similar organisms. This view forces us to reconsider what evolution is.

One can imagine applications to biomedicine and robotics, and one can ask whether the term robot is anymore appropriate. This vision raises deep questions in ethics, which is based on the view that life forms are products of long evolution and has been strongly human centered. What are the universal principles of ethics, is the question.

The basic critical question is that the notions of cognition, intelligence, self, multiscale competency, goal, and evolution are not defined at the deeper, presumably quantum physical level. Quantum physics as we now understand it, does not of course allow the formulation of these notions. The same applies to the notions of memory, and self, goal or intention. These notions would require a theory of conscious experience telling what distinguishes living systems from dead systems (if such even exist).

12.2.3 The dream

The dream of Levin [I156, I137] is to understand, recognize, create, and relate to truly diverse intelligences regardless of composition or origin story. Besides understanding of familiar creatures one would understand colonial organisms and swarms, even say something universal about exobiological agents. This would make possible synthetic biology, bio-inspired AI.

Communication with cell groups allows rewriting of the morphogenetic goals. Rewriting would be like activating one particular program module in the hierarchy of program modules. This module would call lower levels modules and in this way recruit the agents at the lower levels of the scaling hierarchy. No knowledge of the details of the process at lower levels would be required. This approach is a diametric opposite to the usual approach based on gene level manipulations.

One can even dream of the emergence of an anatomical compiler, which assigns to a plan of an organism, generated using AI utilizing the available empirical data, a new organism with desired functions. This dream is of course very far from reality. Levin mentions as an example the chimeric embryo formed from azoloti larva and frog larva. The existing models cannot predict what the outcome of the morphogenesis in this case could be.

Regenerative medicine would provide obvious applications for this kind of compiler. Consider only birth defects, degenerative diseases, aging, and cancer. Reprogramming a multicellular level could allow to normalize tumors, repair birth defects, induce regeneration of limbs, etc... Levin mentions also the development of electroceutical drugs based on chemical manipulations of cell membranes. What ions? What ion channels? These would be the basic questions?

Also other than biochemical tools for the programming of the morphic goal might be possible but this would require a deeper understanding of how the goal identified as a memory is represented. Here quantum biology could come to rescue. One should understand how the goal as memory is defined at quantum level and how the manipulation of the voltages assigned to ion channels affect the goal.

One can imagine applications to computer science, say bio-computers for which search corresponds to finding a goal in the morphospace. Whether this can be realized using ordinary computers or even quantum computers relying on the standard quantum theory, is of course far from obvious.

The goal directed behavior could involve the feedback loop involving sensory perceptions about the state of the organism, which are compared with the goal, and generate feedback as a control signal.

One can also imagine a neuro-inspired view of sensory perception as a pattern recognition and completion in which the morphogenetic goal is represented by standardized mental images representing the possible outcomes of pattern completion. One could also consider the bio-inspired analogue of machine learning.

12.3 TGD view of morphogenesis

The TGD inspired view of life and consciousness leads to a view of morphogenesis discussed in detail in [L139] (2022). The discoveries of Levin's group described in [I153, I154, ?] have been discussed in [L23] (2014).

12.3.1 A possible TGD based view of morphogenesis

The basic notions relevant to the TGD description of morphogenesis.

- (a) The notions of magnetic and electric bodies (MBs and EBs). Magnetic flux tubes and possibly also sheets form a network connecting cell membranes and higher level membrane like structures. They correspond to EBs formed by light-like outer boundaries of 3-D surfaces representing the bodies of the network.

- (b) The phases of ordinary matter with effective Planck constant $h_{eff} = nh_0$, tentatively identified as dark matter, play a key role in the TGD inspired quantum biology. These phases can reside at MB and EB. In the models considered hitherto MB is in a key role but it is clear that EB has an important role.
- (c) The notion of genetic code is generalized. One can speak of dark code with codons realized in terms of dark proton - and dark photon triplets. In the number theoretic vision dark genes are realized as 3N-protons and photons. The so-called icosahedral tessellations of hyperbolic 3-space H^3 define a candidate for a universal realization of the genetic code. The genetic code could be realized at the level of cell membranes in terms of ion channels. One representation for the codons as 6-bit sequences could be as graded membrane potentials. The 2-D pattern of codons would define a set of 2-D genes. Electrical manipulations affect these genes and they become dynamical. This could also define what might be called "morpho-genes".
- (d) The electric programming of cell groups by electrical manipulation could affect the 2-D genetic codons, which would define the morphogenetic program. This would be possible at the early embryo state during which the system would be quantum critical. The fixing of membrane potentials of ion channels and pumps could fix the frequency of dark Josephson radiation from cell membranes to MB for them and select parts of MB for which cyclotron frequency is same as for the ion channel. This would map the electric pattern of the cell membrane to MB. After this period the situation would stabilize.
- (e) Zero energy ontology (ZEO) and holography might play a key role. The basic problem is to understand how a goal is realized as a memory. In ZEO the initial state as a superposition of 3-surfaces at the passive boundary of CD would remain invariant during the evolution of the zero energy state. It would naturally define the counterpart of memory and dictate to almost deterministically the evolution of self by "small" state function reductions (SSFRs). The memory would correspond to the part of self which is not changed during the evolution by SSFRs.

The comparison of the zero energy state defining self would in the simplest model be based on communications to the passive (past) boundary of self with negative energy signals with reversed arrow of time. The feedback would be a positive energy signal back to the future. This process essentially pattern recognition and completion and would gradually lead to the goal. This picture is completely general and morphogenesis would have only one particular application. One can consider more complex models in which the information about the goal at the MB is preserved and sensory communication could be also in standard time direction whereas the feedback would be in the opposite time direction. "Big" SFRs (BSFRs) would be involved in both cases.

Pairs of BSFRs involving temporary change of the arrow of time could be involved with large error corrections. Note that the sensory communications to the geometric past and the feedback can be seen as a pair of BSFRs at a lower level of hierarchy.

12.3.2 How the membrane potentials and gap junction connections could define morphogenetic program?

The behavior of the planaria is goal directed. There are reasons to assume that this is quite generally true.

Facts

- (a) The membrane potentials and gap junction connection network during the early embryonic stage code for the goal of the organism in morpho-space.
- (b) After this period, various perturbations, even very dramatic such as mixing of the parts of the embryo, do not prevent achieving the goal and the system is able to correct its

errors. There are several ways to achieve the goal: this is interpreted as intelligent behavior.

- (c) If planaria is cut in pieces, the pieces grow to full individuals so that the memory of the goal is represented in such a way that the splitting does not affect it.
- (d) The modifications of the membrane potential of a full grown planaria and gap junction network do not affect the goal. One can say that the system goal corresponds to a stable memory of what point of the morpho-space the system should reach.
- (e) If membrane potential is manipulated and the planaria is cut after the modification, the resulting planaria have a new goal coded by the new pattern of membrane potentials and gap junction network. For instance, the modification can give rise to 2-headed planaria. If one assumes that the development corresponds to an analog of a computer program, one can say that the modifications lead to new morphology only if the planaria is split.

How could one realize this picture in the TGD framework? In accordance with earlier vision, it is natural to assume that MB, or actually a hierarchy of MBs, defines a slaving hierarchy with levels labelled by the values of h_{eff} defining scale hierarchy assignable to hierarchy of causal diamonds (CDs), which are analogs of cognitive light-cones of Levin.

Especially important levels of the hierarchy are labelled by gravitational Planck constant $\hbar_{gr} = GMm/v_0$ originally introduced originally by Nottale [E2]. Here M corresponds to either Earth mass or solar mass and m corresponds to particle mass. The large values of \hbar_{gr} make possible gravitational quantum coherence in long length scales, even Earth scale. The gravitational Compton length $\Lambda_{gr} = BM/v_0$ does not depend on the value of the particle mass m and the cyclotron frequencies of charge with mass m does not depend on m : this conforms with Equivalence Principle. This view leads to a view about the role of quantum gravitation in biology [L129, L125, L131].

Questions related to the electric coding of the goal

There are several questions to be addressed.

- (a) Why electric modifications have effect only if they are done during the early embryonic state?

The possible explanation is that the MB during the early embryonic period is quantum critical and therefore highly sensitive to perturbations of the biological body represented as modifications of gap junction network and membrane potentials. During this stage the classical pattern of membrane potentials correlates strongly with the state of the MB, which defines the goal as memory. Quantum criticality is later lost and further modifications do not affect the goal anymore.

- (b) How the organ/organism remembers the goal and how the memory can be stable? Here ZEO provides a possible explanation. Zero energy states are pairs of ordinary 3-D states at boundaries of causal diamond CD and represented by superpositions of space-time surface. Holography, which is forced in TGD by the general coordinate invariance, forces almost deterministic correlation between the 3-D states at the opposite boundaries of CD.

The sequence of SSFRs preserves the state at the passive boundary of CD and passive boundary but affects the active boundary and the states at it and the temporal distance (geometric time) between boundaries of CD increases: this correlates the flow of subjective time as SSFRs with the increase of the geometric time. The sequence of SSFRs defines the notion of self as a generalization of the Zeno effect. The state which is unchanged in Zeno effect is replaced with the memory about the goal.

By almost deterministic holography, the state at the passive boundary defines the goal of the system towards which it evolves.

12.3.3 How the potential gradient is generated?

The generation of potential gradients is essential in morphogenesis. Potential gradients play a key role also in the brain functions and the direction of the gradient correlates with the state of consciousness. Potential gradients accompany DNA and microtubules. Hyperpolarization occurring during sleep corresponds to a reduction of the level of consciousness. On the other hand, the direction of a long scale electric field determines whether the brain is conscious or not. Therefore the polarization at the level of neuronal membranes correlates with the direction and strength of the electric field. Why this should be the case, is actually far from obvious, and TGD suggests that new physics, involving quantum gravitation, is involved.

From the videos, I concluded that the potential gradient is generated by manipulating the membrane potentials and that the change of the membrane potential of a given cell is constant and is the same at the two sides of the cell membrane defined by direction of potential gradient. I failed to understand how the variation of membrane potentials in this way can generate a potential gradient along part of the body. The manipulation of membrane potentials of cells such that membrane potential is constant for the entire cell membrane does not generate potential gradient.

Potential gradient means that cells are in an electric field for which potential increases in a given direction and is approximately constant inside a given cell. The simplest expectation is that the membrane potential is modified by the same constant amount for the entire cell.

The membrane potentials should be modified in such a way that the membrane potential is different at different sides of the membrane in the direction of the voltage gradient? Intuitively it is implausible that one could achieve a different effect on the opposite sides of a membrane by using the biochemical methods considered for which cell groups are targets and a single ion channel is selected.

Typically the second end of a structure carrying a longitudinal electric field is negatively charged and the second end is positively charged. How is this polarization generated? It seems impossible to generate it by manipulation of the membrane potentials since the change of potential over over distance defined by the cell is not affected at all unless the charge densities at the cell exteriors are rearranged to generate the gradient.

Does the generation of the potential gradient have anything to do with the manipulation of membrane potentials or is the mechanism indirect? It seems that in the case of the brain this is the case.

In the case of axonal microtubules, I have considered a new physics based mechanism based on quantum gravitation in the TGD sense. The mechanism would also generate a change of polarization in the axonal membrane since the effective microtubular charge in the interior of the axon would change.

- (a) The proposal is that very long "gravitational" hydrogen bonds with length even of order of Earth scale are possible due to the large value of gravitational Planck constant \hbar_{gr} . Ions would be transferred from the microtubule to these long hydrogen bonds and go outside the axon-microtubule system so that the effective charge of the microtubule would change and the transverse electric field created in this way affects the membrane potential. This could give rise to a propagating depolarization giving rise to hyperpolarization.
- (b) In this way it is also possible to create a longitudinal electric field in, say, the head-tail direction of the organism. This mechanism would be at work also in the case of the brain and relate to the DC currents of Becker [J25]. If the modification of membrane potentials generates a voltage gradient, the manipulation of the membrane potential must induce an effective charging of the cell interior. The number of ions transformed to long hydrogen bonds depends on the value of the membrane potential and that the effective charge depends on the value of the membrane potential being for instance proportional to it.

This could allow the MB to control the polarization based on the modification of membrane potentials. Actually MB, would keep it constant at the morphogenetic level. In the case of the brain the direction could be changed when the organism falls asleep (BSFR).

- (c) What the analogue for the choice of a subroutine in the manipulation of embryo or split planarian could mean in TGD? Ionic channels define Josephson junctions and for large values of h_{eff} Josephson frequencies can be even in ELF scale. These frequencies correspond by resonance condition to cyclotron frequencies of dark ions at MB. The resonance condition selects a part of MB to which communication of sensory data is possible and which can control the organism by resonance mechanism. The frequency modulated signal is transformed to a pulse pattern and this pulse sequence could define an analog of nerve pulse pattern [L129]. The empirical findings [I165, ?, I164, I52] and the TGD view of the role of quantum gravitation lead to identification of new kinds of pulses with the voltage scale in mV scale.

The goal of the organ is characterized by an electric field pattern, which in turn is dictated by the membrane potentials assignable to channels, pumps and gap junctions. How could the electric field pattern achieve this? The cells along the linear structure send Josephson signals to different parts of MB. Flux tubes whose thickness and therefore B varies?

Part of the organism corresponds to MB. The magnetic field strength at MB corresponds to the value of voltage at the cell membrane to guarantee resonance in communications. Voltages define a map of an organism at MB. This map is realized only at quantum criticality when the organism is very young and its MB is highly sensitive to the pattern of electric voltages..

12.3.4 How the state of the MB can serve as a template for evolution?

The model for the generation of sensory perceptions, regarded as states of subsystems defining selves, generalizes as such to the development of morphology. The MB contains the representations of possible mental images in sensory perception.

- (a) In sensory perception, the MB carries a representation of standardized mental images. The sensory input to the MB generates a virtual sensory input to sensory organs, which is determined by the difference between the actual sensory input and desired one. This difference is minimized and the process leads to the standardized mental image nearest to the original sensory input.

The process continues until the difference is small enough. The signalling from the MB is based on dark photon signals so that the process is roughly million times faster than ordinary nerve pulse communications so that standardized mental images emerge rather rapidly.

- (b) In the case of morphogenesis, the morphogenetic goal replaces standardized mental images so that the situation is much simpler. The SSFRs define sensory input to the MB and virtual sensory input is replaced with an analog of a motor action, which tends to drive the system towards the goal in the morphospace. There are good reasons to propose that motor actions quite generally correspond to pairs of BSFRs (as analog of death or sleep) changing the arrow of time temporarily and also having interpretation as quantum tunneling events.

The dissipation with the reversed arrow of time looks like self-organization with respect to the original arrow of time and leads to the final state as an analog of self-organization pattern. After the second BSFR the system starts to evolve in the original arrow of time. This pair of BSFRs is analogous to sleep, which is known to have a healing effect.

This mechanism would be used in all biologically relevant scales [L170] and would be a basic mechanism of homeostasis making it possible for a critical system to stay

near criticality by changing the arrow of time repeatedly. This mechanism saves from the basic problem of robotics: robots tend to fall down since the vertical position is unstable. Note that also the dissipation in standard helps to achieve the final state as a self-organization pattern but is not enough if the system is critical as living systems are.

Morphogenesis would be like carving a statue. MB is the sculptor and starting from a rough sketch and proceeding to shorter scales. Now this process from long to short scales would process downwards in the hierarchy of MBs.

- (c) If the passive boundary of CD codes for the goal, the sensory input to it should correspond to signals travelling with a reversed arrow of time. Their generation requires BSFR of the system generating them and a pair of BSFRs would define the signal to the MB at the boundary and the response. Is the same mechanism involved with sensory perception?.

What happens in the splitting of the planaria?

One can say that in the splitting of planaria replication of planaria takes place. What does this mean in ZEO? Does it correspond to BSFR, SSFR or something different. Or are two new CDs identifiable as perceptive fields of new organisms created.

- (a) A natural guess is that MBs and EBs replicate. One of the basic questions in ZEO is whether new CDs can emerge. Since the zero energy states have indeed zero energy at the limit of infinitely large CD, nothing prevents their creation in SFRs. This is prevented by the conservation laws in the standard ontology but not in ZEO. The creation of a CD would correspond to a quantum jump which cannot be regarded as either BSFR or SSFR.

It however seems obvious that standard ontology is a good approximation due to the formation of CD networks in which the CDs are connected by particle lines to form an analog of the Feynman diagram with CDs representing vertices. There the CDs of split planaria would be connected to the CD of the non-split planaria by "particle lines". However, In principle the generation of CDs from vacuum is possible without a violation of the conservation laws.

- (b) The simplest model explaining the findings about the regeneration of planaria from split planaria assumes that each split planaria is accompanied by its own CD and its passive boundary provides the memory determining by holography the growth of planaria as an analog of almost deterministic computer program (quantum superposition of them). The non-split planaria of the geometric past and its CD could still continue to exist and make BSFRs and evolve. This would happen even in astrophysical scales and explain stars older than the Universe and the galaxies older than the Universe detected by James Webb telescope [L135].

12.3.5 Some questions

The findings of Levin et al raise interesting questions in the TGD framework.

- (a) Chinese medicine talks of acupuncture points and meridians. Could these notions be reduced to the hypothesis that ordinary cells form networks analogous to CNS such that communications take place by the analogs of nerve pulses (miniature potentials) in the scale mV scale for which empirical evidence indeed exists [I165, I163, I164, I52] and is discussed from the TGD viewpoint in [L129]. Could the disorders at this level correspond to the loss of quantum coherence at the level of MBs and EBs caused by the reduction of the value of h_{eff} naturally caused by the failure of the metabolic energy feed needed to preserve the distribution of the values of h_{eff} . This would lower the

"IQ" of MB and the control would fail. Could the splitting of the gap junctions be due to the same reason?

This would suggest that the healing of disorders could reduce to the control of communications between EBs and MBs and basically to the control of Josephson frequencies (membrane potentials) and cyclotron frequencies (magnetic field strengths coded by the thickness of the monopole flux tube). Besides chemical tools other tools can be imagined. For instance, irradiation at desired frequencies might be such a tool avoiding the side effects of the chemical tools [L65].

- (b) The vision of ZEO has developed slowly and the question whether BSFR and SSFR are the only quantum jumps or whether new CDs can be created from vacuum. The model for the splitting of planaria suggests an affirmative answer to this question.
- (c) A second open question has been whether the passive boundary of CD carries conscious information. The holography of consciousness suggests that the conscious experience at a given level of the self hierarchy remains constant between two subsequent SSFRs. The quantum state at the passive boundary is unaffected in SSFRs so that one can argue that there is no conscious experience giving information of the passive boundary. Could "silent wisdom", determining the goal of the self by holography, characterize the contribution of the passive boundary. Could the state of the passive boundary define "Self" or "soul" as a conscious experience, which tends to be masked by the contributions of the active boundary of CD. This "Self" would be changed in BSFRs.

12.4 About the recent findings of Michael Levin's group

I watched a video discussing two articles just published in Nature (thanks to Marko Manninen for the links). Besides Michael Levin present was Gizem Gumuskaya from the team behind the first article [I89] "Motile Living Biobots Self-Construct from Adult Human Somatic Progenitor Seed Cells". Also Angela Tung from the team behind the second article [I112] "Embryos assist morphogenesis of others through calcium and ATP signaling mechanisms in collective teratogen resistance" participated in the discussion.

It seems that the findings of Levin's group [I153, I154, ?] are really revolutionizing biology. The Darwinian vision of life as a struggle for existence is being replaced by life as survival based on cooperation, where conscious collective intelligence plays a key role. The findings suggest that life forms can be artificially created for various purposes: the applications in medicine can only be guessed at.

I have written a couple of articles [L23, L73, L160] about the observations of Levin's team. These ideas are emerging outside of biology as well: I have considered Gershing's vision of self-building machines from a TGD perspective in the article [L153].

12.4.1 A summary of the findings

A brief summary of the approach and findings of Levin's team [I153, I154, ?] is in order.

Epigenesis as means to produce new phenotypes

Instead of genetic engineering, epigenesis would serve as means to produce new phenotypes.

- (a) Epigenesis can produce completely different outcomes even though the genes are the same: genetic determinism must be given up. Electric fields of the cell membranes in the embryonic stage control epigenesis, but in the adult phase they no longer have an effect. Different phenotypes can be produced in a controlled manner. How epigenesis is realized under the control of electric fields is a mystery.

- (b) In the approach of Levin's team, there is no need to construct new genomes as in genetic engineering: the same end result, the phenotype, can be achieved with several genomes. Genetic determinism, i.e. the idea that the whole organism is encoded in genes, would be simply wrong. The protein-coding parts of the genes determine the protein level, but the phenotype would be determined by morphogenesis, which would be based on epigenesis.

A fascinating question is how independent the phenotype actually is on the genome. This kind of independence would be analogous to the substrate independence of AI based consciousness. In TGD this would conform with the idea that the magnetic body (MB) is the boss and controls the biological body so that the genetic code would be basically a code used by communication and control signals.

- (c) Epigenesis means that the same basic genome can code for a wide variety of mRNA molecules, which in turn code for proteins: even an mRNA chain does not determine proteins unambiguously, but can be split into parts (slicing), some of which determine a protein. This makes cell differentiation possible, only a small fraction of the genes is expressed, just like only a small part of the modules of a word processing program are in active use.

The realization of epigenesis relies on chemical modifications of DNA, such as DNA methylation and histone modification, which prevent normal gene transcription locally. Epigenetic expression can vary even on a time scale of hours. On the other hand, epigenetic modifications can be passed on to subsequent generations. What controls epigenesis is not understood. It is not even clear what epigenesis should include: should one just say that epigenetic is all that is not genetic. The notion of morphogenetic code emerges naturally.

Membrane potential as a new control level during embryonic stage

- (a) Already the earlier observations of Levin's team demonstrated that there is a completely new level of control that has been ignored before: the electric fields associated with the cell membrane, which are central to neuroscience but ignored in biology. Only the embryonic stage is sensitive to the effects of the electric fields so that these electric fields can control epigenesis only during this stage. The vision is that there is a multi-level control hierarchy above the genes that could extend even to the population level.

For instance, in the case of frogs it is possible to induce dramatic modifications of the phenotype such as several heads or no head at all. These modifications are stable and inherited by the next generations.

- (b) This inspires the idea of creating life forms, biobots, but without applying genetic engineering. Only epigenesis is utilized and has been controlled by manipulating the electric fields of the cell membrane in different ways, for example chemically or using external electric and magnetic fields at the scale of the embryo.

From frog embryos to human cells and populations of embryos

Earlier simple life forms such as frog embryos were studied, but now human cells have been the target and the earlier observations are made also now.

- (a) In the past, xenobots were studied as artificial life forms built from frog cells. For example, cells taken from epithelial tissue can be used. The important thing is that the system is sensitive to the control of the electric field of the cell membrane only in the embryonic stage and the genetic expression stabilizes after that.
- (b) Now anthrobots [I89] have been studied as artificial life forms formed from human cells. The spheroid shape group of cells generated under normal conditions is transformed by external stimuli so that the usually inward-directed cilia point outward and the structure can move with their help. Embryo is turned inside-out.

- (c) The population formed by the embryos has also been studied [I112] and unexpected collective effects have been observed. The collective survives a perturbation better than a mere individual. The vision of vulgar Darwinism about life as a struggle for existence (to which also our materialistic view of society relies on) is simply wrong.

12.4.2 TGD view of the findings

Consider now a summary of what has been observed from the TGD perspective.

Structure determines function

It seems that at the level of the organism, the 3-D structure determines the function and that these functions are a discrete set in the studied situations. This is highly non-trivial but in line with the TGD vision, which differs from the standard physics in the sense that holography is realized at the space-time level.

3-D surfaces in $H = M^4 \times CP_2$ identified as a generalization of point-like particles of quantum field theories is the starting point of TGD. The 4-D spacetime surface is determined from the 3-D surface providing holographic data and is therefore analogous to the Bohr orbit. The almost deterministic Bohr orbit is analogous to the notion of function of biology, a genetic program determined the structure having 3-D holographic data as a counterpart. Quantum states are superpositions of these Bohr orbit-like space-time surfaces.

What distinguishes TGD from other quantum theories is that there is no path integral so that one avoids the usual divergences and classical physics becomes an exact part of the theory.

In particular, the fact that there seems to be a very small number of different structures and associated functions conforms with holography.

At the quantum level, biological functions are time evolutions that obey statistical determinism. What distinguishes biosystems from deterministic computers is that statistical determinism can be violated because quantum coherence in all scales is possible. Quantum coherence in time scales longer than say the EEG periods implies this violation. This is what makes matter alive. An interesting question is whether this violation can take place also for ordinary computers.

Cells behaviour depends on the size of the population

- (a) A surprising result of [I112] is that cells behave differently depending on the size of the population. Furthermore, cells, embryos, etc... are cooperative social beings helping each other to survive. For example, in a population, a single cell recovers from damages much better than a solitary cell. This happens only if the entire population has experienced the same perturbation. Cells survive better in a larger population and develop differently in them.
- (b) This strongly suggests the presence of collective consciousness and intelligence, which is much more than what is thought to be, for example, the swarm intelligence of AI systems. The magnetic body (MB) as a conscious entity could provide the TGD realization of collective intelligence and produce a hierarchy of levels of consciousness. The bigger the population, the larger the value h_{eff} as a measure of algebraic complexity and quantum coherence scale also at the level of the individual: this would explain why the increase in population size makes individuals smarter too.
- (c) When a single cell of the population is damaged, it generates a Ca^{++} wave that spreads to the environment and induces ATP production and Ca^{++} secretion. This involves the transfer of information, which makes it possible for the population to react as a coherent entity, a kind of life form. If the Ca^{++} wave or the generation of ATP is blocked, the embryos behave as if they were alone.

Communication need not involve mere chemical signals, as the standard biology would predict. It is not understood how the mere presence of other individuals helps in the healing process.

- (d) What could be this unknown means of communication? This brings to mind the observations of Blackman and other pioneers: ELF radiation at the cyclotron frequency of Ca^{++} in the case of mammals affected both behavior and brain physiology. In the TGD framework, the generation of a Ca^{++} wave could correspond to the communication induced with the help of Ca^{++} ions to a certain layer of the system's magnetic body. Communication would take place at the cyclotron frequency and its multiples, which in Blackman's experiments was 15 Hz and would indicate the presence of an endogenous magnetic field of .2 Gauss, which is $2/5$ of the nominal value of the Earth's magnetic field.

Ca^{++} waves could act like neurotransmitters are believed to do, that is by activating communication lines from cells to the MB. The embryos would become a coherent unit through these connections. The MB would control the entire system. Quantum entanglement in the scale of MB would be present making the population a coherent unit: mere classical communications are not enough.

- (e) A nerve impulse would do the same between neurotransmitters. Here one should think critically about the previous TGD view of the role of nerve impulses. According to the TGD view of brain [L50], nerve pulses do not correspond to fundamental communications. Rather, neurotransmitters would simply connect the magnetic flux tubes associated with pre- and postsynaptic neurons to form one long channel along which dark photons with large \hbar_{eff} would propagate from the sensory organs to the cortex and from cortex to the MB.

A more general alternative would be that dark photons signals to the hierarchy of layers of the MB of the brain take place also from the activated neurons along the neural pathway and not only from the cortical neurons. The activated neurons, the neuronal pathway, would have a quantum coherent and quantum entangled entity at the level of MB and define an association chain at the level of conscious experience. Neuronal synchrony would relate closely to this quantum coherence.

Morphogenetic code

The proposed communications should involve a morphogenetic code, which is not understood.

- (a) TGD inspires the idea that the genetic code as a universal code defines also the morphogenetic code [L73, L139]. Dark codons of DNA, RNA,... and their counterparts would be realized as dark proton triplets in various scales. Dark genes with N codons would correspond to $3N$ dark protons. Communications would rely on dark $3N$ -photons (N would correspond to the number of codons of gene) as analogs of bound states of $3N$ dark photons would realize the genetic code in the sense that they would induce $3N$ -resonant transitions between dark genes as dark $3N$ -protons.
- (b) Also the communications between dark and ordinary information molecules would rely on the resonance mechanism. The idea that dark genes are mere copies of ordinary genes does not look attractive. Actually, dark DNA, RNA, etc could be almost independent of their chemical variants and participate in quantum information processing not directly visible at the level of ordinary biomatter. Only in the communications with ordinary gene or its part, dark information molecules could transform to a state corresponding to the ordinary information molecule or its part.
- (c) The realization of the genetic code could be universal and could correspond to the so-called icosahedral tessellation of the hyperbolic 3-space and it would appear in all scales, not only in biology [L144].

Hierarchy of collective intelligences

Levin proposes that collective intelligence is present in several scales. TGD predicts the existence of several scale hierarchies based on a new view of spacetime and a number-theoretic vision of TGD as dual to geometric vision.

I have built a model for the birth of language [K147] based on the observation that the appearance of a few crucial genes was crucial for the emergence of language. The proposal is that this meant the appearance of a layer of MB with a considerably larger h_{eff} . A collective level of consciousness on a much larger scale was born. Language would make possible the communication between individuals and promote the birth of these larger collectively conscious structures. Language in human society would have a role similar to that of Ca^{++} waves in the collective behavior of embryos [I112].

Somewhat surprisingly, Levin does not speak at all about the possible role of quantum theory in biology. I think it would be important to build a bridge from the observations of Levin's group to the models of quantum biology. The team's findings force us to take quantum coherence at long scales seriously.

Typically, theories of consciousness do not have much to say about this aspect. One reason, of course, is that standard quantum theory doesn't have much to say.

Chapter 13

Molecular Signalling from the TGD Point of View

13.1 Introduction

I learned recently about interesting findings about communications of information molecules. The Quanta Magazine article "*Biologists rethink the logic behind cells molecular signals*" (<https://cutt.ly/iA281qn>) summarizes the findings of Elowitz *et al* described in the article "*The context-dependent, combinatorial logic of BMP signaling*" [I91] (<https://cutt.ly/yA8r07b>).

13.1.1 Observations

Messenger molecules attaching to receptors are thought to be responsible for chemical communications. Intercellular communications would involve first messengers (hormones, neurotransmitters,...) and intracellular communications second transmitters, which are not proteins but rather light molecules.

The standard interpretation has been that messenger molecules themselves define the message. Lock-key hypothesis states that the ligand has a special region (key), which attaches to the receptor in a context independent way determined by the geometries of these regions. Induced-fit hypothesis states that the regions in question can modify their surfaces to achieve a perfect fit. For bacteria only intracellular communications are possible and for them there is evidence that in some special cases lock-and-key principle works as was demonstrated by Michael Elowitz, the leader of the research group behind the recent work.

The findings of the Elowitz and his coworkers force them to conclude that this model fails for the multi-cellulars.

- (a) The group studied so-called bone morphogenetic proteins (BMP) (<https://cutt.ly/oA7kZna>), which regulate how cells proliferate and differentiate in various tissues by directing them to turn sets of genes on and off. These proteins have many other functions than bone growth.
- (b) BMPs are so-called 1st messengers and mediate communications between cells. BMPs attach to the receptors of various types at the surface of the cell. This step is followed by signal transduction activating the corresponding signalling pathway. Eventually this leads to a generation of transcription factors in the cell nucleus controlling the genetic response. The work concentrated on the study of the binding of BMPs to the receptors at the cell membrane.
- (c) Mammals have genes that encode 11 or more distinct BMP proteins. BMPs occurs dimers of the same or different proteins and also these pairs can pair up. The family

of BMP proteins sticks to the associated family of receptor proteins, which also appear as dimers of pairs of them. BMP molecules are not very selective but given BMP sticks to several dimer pairs of receptors.

Several interesting findings were made.

- (a) The response of a cell to several ligands is not simply the sum of responses of individual ligands. The lock-key mechanism assuming 1-1 correspondence between ligands and receptors fails in the presence of several ligands whereas for a single ligand there is strongly preferred receptor for a given ligand.

The simplest chemical (and thus local) explanation that in presence of several ligands the affinities K_{ijk} of ligands L_i to the receptors R_{jk} formed by dimers (j,k) of homologous or nearly homologous molecules change so that approximate 1-to-1 correspondence becomes 1-to-many. This is called promiscuity.

The responses as concentrations at the cell membrane for the activated signalling pathways P_{ijk} associated with receptor i+jk would be still linear in concentrations of L_i but the matrix characterizing the rate for the creation of P_{ijk} would not be diagonal matrix anymore with respect to pairs (i, jk) .

- (b) This situation is easy to model mathematically but it is difficult to understand the physical mechanism behind the promiscuity.
- (c) The affinities are context dependent in the sense that they depend on the target cell and the developmental stage of the cell.
- (d) One can classify the ligands in terms of whether they tend to increase or reduce receptor expression. Ligands can be also classified in terms of their positive, or negative synergies with other ligands. In the simplest situation one studies all possible pairs of ligands and finds their responses. Two ligands L_i and L_j are regarded as equivalent if the responses for the pairs (L_i, L_k) and (L_j, L_k) are identical for all k . This defines functional equivalence. Sequence similarity (biological homology) does not in general reflect the functional equivalence.

The effects of the ligands in equivalence classes depend on the context (cell type and cell age correlating with receptor concentrations). However, it is found that the equivalence classes are context independent. The proposal is that a single linear parameter could characterize the equivalence classes for BMPs considered.

- (e) This inspires a chemical model for the situation. The basic parameters would be affinities K_{ijk} telling the tendency of ligand L_i to attach to dimer (j, k) , signal complex activities ϵ_{ijk} characterizing the rate for the formation of signal complex P_{ijk} . Also the receptor concentrations A_i and B_i for the receptors of type I and II appear as parameters. The empirical data makes it possible to find the best fit for the parameters. Promiscuity is the basic prediction. The model could be understood in terms of the competition of ligands for receptors (j,k).

An inverse relationship between affinities and activities is predicted. Small number of affine ligands with weak activity or vice versa.

13.1.2 TGD view about the findings

What can one say about the situation in the TGD framework? Here only the key ideas of the TGD inspired quantum biology are described. More detailed summaries can be found in various articles related to dark variant of biochemistry [L173, L51, L111], to dark realizations of genetic code [L22, L96, L81, L108, L141], and to the models for cell membrane as generalized Josephson junction [K96, K44, K98] [L104], of Pollack effect [?], and of water memory and morphogenesis [K58] [L139].

- (a) The basic notion is magnetic body (MB) carrying dark matter as $h_{eff} = nh_0$ phases of the ordinary matter and behaving quantum coherently in length scale proportional to h_{eff} . MB would control biomatter.

Communications to MB, sensory input, would be in terms of generalized dark Josephson radiation from the cell membrane and the control by MB in terms of dark cyclotron radiation. The sensory input would be from the entire cell membrane and induced by the attachment of the ligands to the receptors.

The earlier proposal was that the control signals from MB affect directly the genome. The existing chemical picture based on signal pathways activated at the cell membrane however suggests that the situation is not so simple. The control signal arrives from MB to the receptors and activates signal pathways. At the nuclear membrane similar processes would occur and lead to the activation of transcription factors by similar signal pathways.

- (b) If the MB determines the response of receptors in a non-local way, promiscuity could be only effective. Another option is that MB can control the affinities of receptors (by modifying their surface geometries as in the induced fit model) so that the diagonal L-R matrix becomes non-diagonal.
- (c) Context dependence would conform with the idea that MB determines the response and changes during aging. The aging can be understood in the TGD framework as slow thermalization of MB so that its temperature approaches the Hagedorn temperature of magnetic flux tubes. Physiological temperature would be related very closely to Hagedorn temperature of MB.

The almost computer program-like determinism of biochemistry is in a sharp conflict with the stochasticity expected to result from the locality and statistical nature of chemistry.

- (a) In the TGD framework and at a given level of scale hierarchy the dynamics of the space-time surface as a preferred extremal is deterministic apart from small violations of determinism. Space-time region as a preferred extremal is a minimal surface with singularities, which would bring in the failure of determinism. Soap film with frames serves as a good analogy.
- (b) The notion of a magnetic body having flux tubes as body parts leads to a model of bio-catalysis in which molecules are replaced with nodes of flux tube network. Molecules can find each other as part of this dynamical network involving reconnection of U-shaped flux tubes and their shortening in a reduction of h_{eff} liberating energy making to overcome the potential wall making the reaction low.
- (c) One can argue that the second law implies stochasticity in molecular scales. Zero energy ontology (ZEO) is another possible source of determinism. In so called "big" state function reductions (BSFRs) the arrow of time changes and the time evolution leads to the direction of geometric past so that for the observer with the standard arrow of time the time evolution obeys second law in wrong time direction and looks like self-organization which is basic characteristic of living matter and usually thought to involve metabolic energy feed in an essential way. In fact the time reversed time evolution would change dissipation as loss of energy with extraction of energy from the environment.

The findings of Elowitz *et al* [I91] lead to a formal model suggesting that ligands of type BMP have interactions. The interactions would be non-local so that that they could have chemical origin. The TGD based model for these long range interactions is based on dark photon resonance. For the simplest, receptors would correspond to fixed bio-harmonies. In a single ligand system the ligand would have the bio-harmony of its preferred receptor. The interaction between ligand magnetic bodies would be re-tuning and could replace the

preferred bio-harmonies assignable to the participating ligands with distributions of bio-harmonies. Therefore the ligands of the multi-ligand system would couple by bio-resonance also to other than preferred receptors.

The model stimulates questions, which lead to a rather detailed model for the re-tuning and tuning processes at the level of codons and amino acids. The model suggests that the tuning to a given bio-harmony for the dark counterparts of basic biomolecules and its stabilization involves epigenetic control based on the methylation of some special DNA and RNA nucleotides and amino-acids acting as analogs of tuning forks.

The proposal that bioharmonies are molecular correlates for emotions suggests that this process involves minimal number of methylations, which define the seed of phase transition to a bio-harmony in the scale of the basic unit of genome (such as gene), mRNA sub-unit (splicing) and protein sub-unit.

13.2 Bio-harmony and context dependence

Also bio-harmony might relate to context dependence if fundamental communication and control signals take place at the dark level that is between DAAs instead of AAs (amino acids) as parts of proteins by energy and frequency resonances. DAAs would pair with AAs and communicate with energy resonance.

13.2.1 Bio-harmony

Consider first the bio-harmony [L22, L81, L96, L141] in more detail.

- (a) Z_6 , Z_4 , and $Z_{2,rot}$ or $Z_{2,refl}$ act as symmetry groups for the 3 icosahedral Hamiltonian cycles. Each cycle, one of type XZ_6 , one of type Z_4 , and one of type Z_2 , defines 12-note scale and 20 3-chords identified as icosahedral faces and DNA codons. The notes along the cycle are obtained as a quint cycle, that is by scaling the frequency of the note by factor $3/2$ at each edge of the oriented cycle.

The orbits of faces under Z_n are assigned with amino-acids (AAs). This assumption has a concrete interpretation in terms of resonance mechanism for bio-communications [L141].

This gives 60 3-chords and the numbers of triangles at the orbits of triangles and the numbers of triangles at orbits correspond nicely to the numbers of DNA codons coding for AAs. 4 codons are however missing. The fusion with a unique tetrahedral code gives 64 chords and a dark 3-photon realization of the genetic code.

Also the identification of DtrRNA, dtRNA, and DAA in terms of icosahedral code is possible as found quite recently [L141]. Also the dark realization of genetic codons in terms of dark proton triplets allows this.

- (b) Z_6 allows unique icosahedral harmony defined by 12-note scale realized as an icosahedral Hamiltonian cycle. The corresponding AAs correspond to 3 DNA 6-plets and one DNA 2-plet. Z_4 corresponds to 2 bioharmonies with 5 amino-acids which correspond to DNA 4-plets. $Z_{2,rot}$ and $Z_{2,refl}$ correspond to 10 2-plets both. $Z_{2,rot}$ corresponds to 3 icosahedral harmonies and $Z_{2,refl}$ to 5 icosahedral harmonies. This makes $1 \times 2 \times (3 + 5) = 16$ bio-harmonies if the common key of the 12-note scale for the 3 icosahedral harmonies does not matter and the orientation of the Hamiltonian cycle does not matter. One can also consider the possibility that the key and the orientation of the cycle for the 3 icosahedral harmonies matter. The change of the orientation replaces quint cycle with quart cycle (CG corresponds to quint and CF to quart).
- (c) The interpretation of bioharmonies is as correlates for moods, emotional states. There is evidence for this interpretation from the strange finding that RNA is able to transmit conditioning based on negative or positive emotions generated by stimulus (<https://>

cutt.ly/6SuLNqk) discussed in the TGD framework in [L69, L85]. The interpretation would be that DRNA represents the effect of stimulus by its bio-harmony characterizing emotional state, and can induce molecular emotional expression in DDNA-DNA pairing and also in DAA-AA pairing and DX-X pairing in general.

DX-X pairing by energy resonance mechanism would correspond to emotional expression. Something in X would depend on bio-harmony. In the case of DNA and RNA this something could be the methylation state and its analogs so that there would be a direct connection with epigenesis. Epigenesis would realize the dynamics of emotional expression.

One can raise several questions about bio-harmony.

- (a) How fast is the dynamics of the molecular and higher level emotions and moods? If epigenetics controls the dynamics of emotions, it could be rather fast at the molecular level. Note that the hierarchy of Planck constants predicts a hierarchy of time scales.
- (b) How large parts of a given organism a given bio-harmony could characterize? Biomolecules, cell nucleus, cell, organelle, ...? Is there a hierarchy of harmonies so that the harmonies in different scales need not be identical?

Concerning molecular bio-harmonies, epigenetics could help to answer the question. For instance, one can ask whether bio-harmony characterizes individual bio-molecules such as enzymes and receptors.

- (c) Could bio-harmony explain at least part of the context dependence found in the ligand-receptor dynamics by the group of? It would seem that bio-harmony appears as an additional aspect of the ligand-receptor pairing involving geometric constraints modelled in terms of lock-key or induced-fit mechanisms. The enzyme and substrate would be like daters. The resonance mechanism would allow E and S to meet and geometric constraints would determine whether this can lead anywhere.
- (d) This inspires several questions. Could the affinities and signal complex activities be determined by the molecular emotional state of the L-R composite coded by the bio-harmony of the DX-X complex? Could the "emotional" state DX-X control affect the state of X complex? How? Could this coupling have interpretation as emotional expression in a generalized sense?
- (e) For the simplest model this would predict that for Z_4 the 5 AAs coded by 4 DNA codons would have two emotional states and for Z_2 10 DAA-AA pairs could have 3 *resp.* 4 emotional states depending on whether one has $Z_{2,rot}$ *resp.* $Z_{2,refl}$.

13.2.2 Could ligand interactions reduce to a re-tuning of ligand harmonies?

The notion of ligand interaction has been introduced as a purely formal notion in the article and it is difficult to imagine a local chemical realization for it. However, the fact is that ligands change their behavior in the presence of other ligands. Could the ligand interactions be realized at the level of their MBs?

Ligand interactions as re-tuning

Could ligand interactions reduce to the re-tuning of ligand harmonies by the resonant dark photon interactions between DAA flux tubes?

- (a) Assume that ligands and receptors can have several bio-harmonies but that free ligands (single ligand situation) and in the absence of other ligands they correspond to single preferred bio-harmony. Assume that each receptors corresponds to a single bio-harmony

(also this assumption could be relaxed). Free energy minimization could imply preferred bio-harmonies for both receptors and ligands. Assume that ligands can only pair with receptors with the same bio-harmony. The immediate question is whether the 3+4 receptors assigned with BMPs could relate to 3+5 Z_2 type harmonies. The problem is that one $Z_{2,refl}$ harmony would not correspond to a receptor.

- (b) Interactions between two ligands L_1 and L_2 with different bioharmonies could induce a re-tuning of L_1 to the bio-harmony of L_2 or vice versa. This tuning must respect the symmetry group Z_n , $n = 6, 4, 2$ in question. The Z_n orbits would be preserved but the corresponding 3-chords would be modified.

Some findings about water memory [L139] support re-tuning as a basic mechanism of communications between dark biomolecules and it is very natural in the resonance picture. Note that re-tuning is a basic mechanism in radio communications.

Re-tuning would replace the ensemble of ligands with an ensemble in which also non-preferred L-R pairings are possible. It would make the affinity matrix $K_{i(jk)}$ and activity matrix $\epsilon_{i(jk)}$ non-diagonal and induce promiscuity. Probability distribution for bio-harmonies of ligands would emerge in this way.

- (c) The large-scale quantum coherence at the level of MBs inspires the question whether the quantum superposition of bioharmonies could occur for DAAs.

Could quantum superposition allow to understand the observation that the increase of the parameters $K_{i(jk)}$ is accompanied by the decrease of $\epsilon_{i(jk)}$ and vice versa. Could one think that with a suitable normalization one has $\sum_{(jk)} K_{i(jk)} \epsilon_{i(jk)} = \text{constant}$. In ZEO one could regard the entire signal complex, which involves both ligand, receptor and what it induces, as a single zero energy state as a superposition of deterministic time evolutions.

If the formation of signal complexes involves a quantum transition from a single ligand-receptor pair to a their quantum superposition involving delocalization at the cell membrane followed by state function reduction involving localiation that is selection of the complexes, the condition $\sum_{(jk)} K_{i(jk)} \epsilon_{i(jk)} = \text{constant}$ could reflect probability conservation.

- (d) Re-tuning of the icosahedral harmony for Z_4 and Z_2 should have a counterpart affecting the physics of AAs. Could the re-tuning be generated at the level of DAA and result from the variation of flux tube thickness as a motor action of MB? Or could it be induced by re-tuning at the level of DDNA? Tuning must be visible at the level of AAs since DX-X resonance energies must be modified.

Tuning and re-tuning at the level of DX-X pairing

What could the re-tuning mean for the DX-X pairing?

- (a) For DDNA-DNA pairing dark cyclotron photons must couple to some degrees of freedom of DNA. In the TGD framework, DNA can be magnetized [L139]. The pairing with DDNA flux tubes carrying a monopole flux with DNA strands is expected to induce magnetization along DNA due to the ring currents of electron pairs of the aromatic rings analogous to Cooper pairs.

The simplest candidates for re-tuned frequencies are cyclotron frequencies for magnetized nucleobases. In re-tuning the cyclotron frequencies for electron pairs) assignable to aromatic rings of nucleotides would be modified in re-tuning. The change of the thickness of the monopole flux tubes defining the 12-note scale would automatically induce the re-tuning at DNA level. The re-tuning could be induced by DDNA, DRNA, and DtrRNA and would not require chemistry.

- (b) What about the DAA-AA tuning? The only AAs with aromatic rings are Phe, tyr and trp. Could DAA-AA resonance coupling between cyclotron radiation of DAA and

vibrational modes of AA with energies in the range .45-.045 eV spanning slightly more than 3 octaves?

The general forms of the vibrational and cyclotron energy spectra are the same and for a proper value of h_{eff} the scale of the DAA spectrum is the same and resonance is possible.

Re-tuning would require change of the conformations of the AAs so that the elastic constants would be modified. MB could induce this re-tuning as a kind of entrainment. As already proposed, this could be achieved at the level of DNA by methylation of the start codon fixing the bio-harmony.

Could special 3-chords act as tuning forks

Physical model for the tuning and re-tuning should be based on resonance model.

- (a) Tuning to a particular 3-chord or 3-chords should force the entrainment to the bio-harmony. These 3-chords would serve as an analog of a tuning fork.

The simplest, and perhaps unrealistic, option is that the met 3-chord associated with the start codon alone fixes the bio-harmony uniquely. The met 3-chord should be different for all Z_2 harmonies.

- (b) The chords fixing the bio-harmony (the tables for the 3-chords of bio-harmonies are given in [L22]) should be very special and thereindeed are very special chords in the icosahedral harmonies. The epigenetic modification of the amino-acids corresponding to these 3-chords could force the re-tuning of the bio-harmony.

The triangles, whose edges do not belong to the Hamiltonian cycle, define 0-quint 3-chords containing no quint. These chords include dissonant chords possibly having semitones or tones intervals between the notes (octave equivalence and quit cycle along the Hamiltonian cycle is assumed). There are 8 different types of 0-quint chords with basic note X in 12-note scale labeled as $Xexk, k = 1, \dots, 8$, if the key does not matter.

- (a) From the Appendix one learns that there the first possess no 0-quint chords Z_4 harmony. In this case, one could argue that the bit defined by the presence or absence of the 0-quint chord defines the tuning fork, which could correspond to a methylation of some codon coding for one of the 5 AAs coded by DNA 4-plet. It is not clear, whether the choise of the codon matters.
- (b) By looking at the tables of 3-chords in the chord tables of the Appendix, one finds that if key matters, it is easy to distinguish between harmonies using a single 0-quint chord. If the key does not matter, it is in principle almost possible to assign different 0-quint chords to, say, met. There are 2 $Z_{2,refl}$ harmonies with 2 0-quint chords, which cannot be distinguished in this manner. If one introduces a fixed key or uses a second special 0-quint chord as a turning fork, also $Z_{2,refl}$ harmonies can be distinguished from each other.

Interestingly, the number of BMP receptors possibly assignable to $Z_{2,refl}$ is 4 rather than 5.

- (c) Also tetrahedral codons define special chords in the sense that the intervals are separated by minor third. These 3-chords are identical under the octave equivalence. In the model considered in [L141], 3 of them correspond to stop codons whereas the remaining codon corresponds to trp.

Re-tuning as an epigenetic process

Re-tuning is an epigenetic process and can be seen as a control of MB. Methylation and its analogs are basic tools of epigenesis.

- (a) mRNA methylation (<https://cutt.ly/1Srm06F>) occurs after transcription and is controlled by genes coding the needed enzymes. The methylated RNA nucleobase is often called the "fifth RNA" base. Start codon AUG coding for met is methylated as also the 3-prime untranslated regions (3'-UTRs) immediately after the stop codon. This region post-transcriptionally influences gene expression.
- (b) The findings that the RNA of a conditioned sea snail scattered over neurons of second sea snail in Petri dish generate neuronal correlates of conditioning (<https://cutt.ly/6SuLNqk>), discussed from the TGD point of view in [L69, L85], support the view that the magnetic body of the RNA of sea snail infects the emotion/mood related to the conditioning. The emotional state, mood, of DNA and RNA would affect gene expression. Epigenesis could be based on emotional states lasting for several generations. This is natural in ZEO [L22, L85].

Hints about how the methylation could be involved with the tuning to a particular bio-harmony comes from the research of the group led by Matthias Soller [I90] (<https://cutt.ly/0SeGnJu>).

- (a) Post transcriptional methylation is known to occur for the few nucleotides of mRNA following the cap of mRNA, whose function has remained poorly understood. Soller and collaborators demonstrated that the two enzymes coding for the methylation of these nucleotides played an important role in the animals' reward learning process. The flies without the genes coding for the methylation showed a defect in their ability to learn the association of a specific odour with a sugar reward.
- (b) Earlier work by one of paper's co-authors, Prof. Rupert Fray, has demonstrated that that cap modifications are highly dynamic in mice and that these modifications played a role in transporting the mRNAs to synapses.
- (c) The lack of methylation implies a lack of the desired conditioning. Conditioning involves emotions, perhaps also at the molecular level: could the bio-harmony of proteins involved with the process differ from that associated with the protein activated by the odour molecules? The proteins would be out-of-tune and conditioning would not happen.

The role of cap modifications in the mRNA transport would conform with the assumption that dark photon resonance allows the mRNA to find synapses. If the bioharmony for them is wrong there is no resonance and the transport fails.

These findings suggest the following interpretation in the TGD framework.

- (a) The resonance mechanism would force DDNA and DmRNA to have the same bio-harmony. The post-transcriptional methylation of the first RNA codon could re-tune and stabilize mRNA bio-harmony.

Stabilization could involve a methylation of a large enough number of special RNA codons so that it would serve as a seed of a phase transition forcing the same bio-harmony for all codons. If bio-harmonies correspond to molecular moods, this would be analogous to the spread of an emotional mood in crowd. The special codons as signatures of the mood could be especially effective inducers of this phase transition.

- (b) Could a 0-quint 3-chord assigned to met in the beginning of mRNA fix the Z_2 harmony almost uniquely by acting as a tuning fork. Z_4 harmony could be fixed by the absence of methylation in some mRNA nucleotide in codon coding for one of the 5 AAs [(val,pro,thr,ala,gly)] coded by 4 codons.

Note that the methylation of 2 AUG nucleotides of met affecting the cyclotron frequencies of AUG could in principle select between the 16 bio-harmonies predicted by the simplest model. This estimate is however based on counting of bits and bio-molecules need not see each other as bit sequences as we do.

The methylation of the mRNAs associated with several 0-quint chords could help to stabilize the Z_2 harmony at the level of DmRNA. Could the proteins obtained by splicing and involving methylation in the beginning of mRNA portions coding them consist of functional sub-units with different bio-harmony?

- (c) What about DNA? Could the methylation of the start codon also now help to stabilize the Z_2 bio-harmony. Only A and C DNA nucleotides of DNA strand can be methylated (as also T and G nucleotides of the conjugate strand). Note that A and G appear often in DNA repeats defining part of what was called junk DNA. One can ask whether the methylation of A and C could stabilize the bio-harmony and DNA level.

The corresponding RNA codon contains at most one U or G nucleotide. Note that met corresponds to AUG whereas AGU corresponds to cys which together with trp (coded by tetrahedral codon) are the only sulphur containing amino-acids. Met is special in the sense that it belongs to a symmetry broken codon doublet for which ile has replaced met.

- (d) The first mRNA codon AUG codes for met so that the D(AUG)-Dmet pairing could induce the DAA bio-harmony and affect the vibrational frequencies of AA. This is perhaps enough for the stability of the bio-harmony. Could protein methylation help to stabilize the bio-harmony of proteins? According to Wikipedia (<https://cutt.ly/uSiVACT>), protein methylation is a type of post-translational modification featuring the addition of methyl groups to proteins. It can occur on the nitrogen-containing side-chains of arginine and lysine but also at the amino- and carboxy-termini of a number of different proteins.

One can imagine 2 options for changing the bio-harmony at DAA-AA level. For the bureaucratic option, the re-tuning would occur at the DNA level. This would require enzymes coded by appropriate genes to re-tune the first codon of mRNA coding for AA.

For the non-bureaucratic option, DAA would re-tune AA directly by entrainment and this could involve re-methylation.

13.2.3 An attempt to concretize the model of ligand interactions

The following is a very naive first attempt to concretize the idea about ligand interactions as a re-tuning, which affects the matrices $K_{i(jk)}$ and $\epsilon_{i(jk)}$. Reader should take the following considerations as free associations.

- (a) BMPs couple to 4+3 receptors. There are 3 Hamiltonian cycles with $Z_{2,rot}$ symmetry and 5 cycles with $Z_{2,refl}$ symmetry assignable to 10 amino-acids coded by 2 or single DNA (met) have 3. There are 4+3 receptors and 5+3 bioharmonies: could it be that the considered 4 receptors correspond to 4+3 Z_1 harmonies with the same Z_4 harmony and that there is also a fifth receptor of this kind but not considered?

A priori, any protein could correspond to any bio-harmony but the correlation of DAA and bio-harmony could be forced by dynamics since the DAA-AA resonances might be possible only for certain Z_2 harmonies (and only for one of the 2 Z^4 harmonies). Suppose that the receptors indeed correspond to one particular Z_2 harmony each.

- (b) If the binding sites for BMP-receptor pairs correspond to single AA (in analogy with tRNA-mRNA binding), the binding site for Z_2 harmonies should correspond to a AA which is one of the 10 AAs coded by DNA doublet or singlet. The reduction of correspondence to the level of binding site AA would conform with the finding that the

functional similarity of BMPs does not very closely correspond to the sequence similarity.

In the code table there are 9 doublet AAs and 1 singlet. Symmetry breaking is present [L141]. It is not quite clear which doublets correspond to Z_2 . For instance, phe could correspond to the doublet for Z_6 leaving 8 doublet AAs plus (ile,met) as a doublet with a broken Z_2 symmetry. UGG coding for trp and 3 stop codons would correspond to the tetrahedral cycle.

By resonance condition, at most 3 receptors should correspond to more than 1 BMP as their preferred receptor.

There are also chemical constraints on the AAs acting as a binding site. Resonance condition for DAAs implies that pairing AAs are identical. The pairing AAs must be neutral and must be coded by DNA doublets or singlets. This leaves the following cases under consideration.

(a) Two amino acids have amide side-chains.

- Asparagine (Asn): $\text{NH}_2\text{COCH}_2-$
- Glutamine (Gln): $\text{NH}_2\text{COCH}_2\text{CH}_2-$

These side-chains do not ionize in the normal range of pH.

(b) Two side-chains contain sulfur atoms, of which one ionizes in the normal range.

- Cysteine (Cys): HSCH_2-
- Glutamine (Gln): $\text{NH}_2\text{-COCH}_2\text{-CH}_2-$

(c) Three amino acids have aromatic ring structures as side-chains. Of these, tyrosine ionizes in the normal range; the other two do not.

- Phenylalanine (Phe)
- Tyrosine (Tyr)
- Tryptophan (Trp)

This would give $2+2+3=4+3$ AAs. In the above mentioned option Phe is however assigned with Z_6 harmony but any other doublet AA could correspond to Z_6 harmony. This would suggest that AAs with amide side chains and containing sulphur correspond to 4 $Z_{2,rot}$ harmonies.

There are 10 BMPs with the decomposition $10=3+3+2+1+1$. Using the standard biological notation, this corresponds to the decomposition [GDF5,GDF6,GDF7], [BMP5,BMP6,BMP7], —BMP2,BMP4],[BMP9], [BMP10]) to functional equivalence classes [I91]. Could the two 3:s correspond to the 3 $Z_{2,rot}$ harmonies and 2+1+1 to 4 of the 5 $Z_{2,refl}$ harmonies?

The two triplets [GDF5,GDF6,GDF7] *resp.* [BMP5,BMP6,BMP7] are weak *resp.* strong activators. Both GDFs (growth differentiation factors) and BMPs (bone morphogenetic proteins) belong to the transforming growth factor beta superfamily (TGF). If GDFs are excluded the correspondence between BMPs and receptor proteins is 1-to-1.

13.2.4 Could the dark matter hierarchy relate to the bio-harmony?

One can wonder how the hierarchy of algebraic extensions and algebraic evolution defining the evolutionary state for a given layer of MB affects the L-R pairings.

- (a) Dark 3N-photons and 3N-nucleons as dark variants of basic information molecules would correspond to Galois confined states for which the 4-momenta for components are algebraic integers summing up to ordinary integer when the momentum unit is defined by the p-adic length scale associated with the extension. Also frequencies would correspond to rational integers for Galois confined states.
- (b) These states depend on the algebraic extension of rationals defining $n = h_{eff}/h_0$ as its dimension although mass squared values and momenta are integer valued as also frequencies. This would give an additional context dependence. For instance, organisms at higher levels of evolution could have larger values of h_{eff} associated with the dark variants of the basic biomolecules.

13.3 Hen egg problem, dark biomolecules, and resonance mechanism

The notions of magnetic body, dark matter as $h_{eff} = nh_0$ phases, dark analogs of information molecules, and resonance mechanism could allow a solution to the hen egg problem of biology: which came first, DNA, RNA, AAs or proto-cell membrane. I have considered the hen egg problem in [K72] and proposed a model of proto-cell in [L92].

Hen egg problem usually means that something is missing from the conceptual picture and TGD based quantum biology suggests what this missing piece could be. The general solution of the problem in TGD would be that dark analogs of information molecules emerged first simultaneously as Galois confined states of dark proton-triplets and dark photon-triplets.

This made possible resonance communications and the basic recognition mechanism by 3-resonance for dark 3-photons. DX-X pairing was based on energy resonance and these composites were able to find each other by resonance. The reduction of h_{eff} for connecting flux tubes in their shortening liberated energy making it possible to overcome the potential wall preventing chemical reactions to occur. This is not as easy as it looks at first since metabolic energy is needed to build the valence bonds and metabolic machinery is absent in early life.

The challenge is to develop a more detailed picture around these basic ideas. I have already earlier considered several proposals for the first steps of the evolution of basic bio-molecules [K49, K50, K72] but without the recent, rather detailed, view about resonance mechanism combined with the notion of dark 3N-photons and 3N-nucleons as dark analogs of basic biomolecules [L141].

13.3.1 Did the DX-X pairing occur simultaneously for all basic biomolecules?

Consider first the pairing of basic information molecules X (DNA, RNA, tRNA codons and AAs). Their polymers are not considered in this section. The simplest vision is that the dark variants of basic biomolecules emerged by Pollack effect [I126, I125, L25, ?, ?] in water irradiated by solar light.

- (a) Pollack effect generated exclusion zones (EZs) as negatively charged regions. Part of protons were transferred to magnetic monopole flux tubes of MBs assignable to water clusters and created phases of water with a hexagonal lattice-like structure.

- (b) An attractive possibility is that the notion of hydrogen bonds generalizes. The monopole flux tubes could be accompanied by hydrogen bonds. This predicts a length scale hierarchy of hydrogen bonds implying long range quantum correlations in arbitrarily long scales and allowing to understand the strange thermodynamic anomalies of water. The length of the dark flux tube is proportional to h_{eff} as also the total energy consisting of Kähler magnetic and volume contribution.
- (c) Galois confinement as a universal bind mechanism would give rise to sequences of dark protons as bound states. The states of dark proton triplet correspond to DDNAs, DRNAs, DtRNAs and DAAs.

The pairing of the dark analogs of biomolecules with ordinary biomolecules to form pairs DX-X gave rise to the observed basic biomolecules. DX-X pairing requires that the ordinary biomolecules have transition energies, which correspond to the cyclotron transition energies of DX for the value of h_{eff} considered. Ordinary cyclotron transitions and vibrational transitions are good candidates in this respect.

- (d) Energy resonance condition for the pairs gives powerful conditions and selects the allowed biomolecules. The selection has not been completely unique. In tRNA the third letter of the chemical codon paired with one of the 32 DtRNAs need not be an ordinary nucleotide and in some viruses adenosine (A) is replaced with 2-amino-adenine ("Z") [I106] (<https://cutt.ly/hSRBSOK>).

13.3.2 Did proto-cell and peptides emerge first?

It is not at all clear whether the dark variants of the polymers of basic bio-molecules can emerge spontaneously. The problem is that the formation of valence bonds requires energy. This forces us to consider the TGD counterparts of the usual purely chemical proposals in which basic building bricks DNA, RNA and AAs form polymers. Now one considers an analog of polymerization at the level of DDA, DRNA, and DAA.

The findings of Montagnier *et al* [I103, I102, I104] discussed from the TGD view point in [L139] suggests that remote DNA replication occurs in absence of DNA template but that the presence of DNA polymerase is necessary. Dark DNA sequences generated by remote replication would appear as a template. This suggests DDNA-DNA pairing could occur by polymerization and require the presence of enzymes and metabolic energy feed.

Could proteins (Ps) have served in the role of egg in the chemical sense in the TGD framework? Could the resonance mechanism together with the TGD view about bio-catalysis make it possible to generate DP-P pairs by a polymerization-like process using DP as a template?

- (a) The large h_{eff} between DP and P would be shortened in a given polymerization step. Energy would be liberated as the dark flux tube bond between DP and P is shortened. This energy should make it possible to overcome the potential wall preventing the formation of the peptide bond and also provide the energy of the peptide bond, which is about .08-.16 eV and considerably smaller than metabolic energy quantum about .5 eV.
- (b) The thermal energy at room temperature using the definition $E_T = kT$ is .025 eV. Second definition of thermal energy is as the energy for which the distribution of black-body radiation as function of energy is maximum: this gives the energy is $E_T \simeq .12$ eV and rather near to the Josephson energy of the cell membrane for charge $Z = 2e$ is about .1 eV.
- (c) The energetic requirements for AA polymerization might be satisfied by using irradiation with photon energy around thermal energy at room temperature. An interesting possibility considered in [K72] and [L92] is that a proto-cell membrane formed from lipids was present from the beginning and before the polymerization. Lipid membranes can form spontaneously and in TGD Universe they act as generalized Josephson

junctions [K96, K98] and induce Josephson radiation, which would make possible communications from cell membrane to MB. Could the Josephson radiation from the cell membrane with energy of order .1 eV provide the metabolic energy for the polymerization process of AAs?

- (d) In the case of DNA and RNA the carbon bond energy between two codons is about 3.2 eV and considerably larger so that the polymerization without enzymes looks highly implausible. Note also that also the formation of lipids is a problem since C-C bonds have energy 3.47 eV.

13.3.3 Empirical and experimental support for the model of peptide formation

There is evidence for amino acid glycine in the interstellar space (<https://cutt.ly/HSYQPmP>) but the independent confirmation is lacking. Also the formation of glycine peptides has been observed in laboratory conditions mimicking the interstellar medium (ISM).

The following summarizes the results described in the article of Serge Krasnokutski *et al* [I94] published in Nature. The following summarizes Krasnosutski's non-technical description of the results (<https://cutt.ly/dSYm1Sn>).

- (a) The ultra-low temperatures, common in astrophysical environments, have been believed to freeze out any chemistry in the dense areas of the ISM. Already the discovery of a high abundance of small organic molecules in molecular clouds was a great surprise. But also the formation of amino acids, nucleobases, lipids, and sugars in space has been confirmed.
- (b) What about the polymers of AAs? It has been conjectured that the condensation of carbon atoms at the surface of dust particles make possible the formation of organic molecules. Serge Krasnokutski *et al* indeed demonstrated the formation of glycine polymers from amino ketenes (glycine corresponds $\text{NH}_2\text{-CH}_2\text{-COOH}$, aminoketene to $\text{NH}_2\text{-CH-CO}$ and polyglycine to $\text{NH-CH}_2\text{-CO}$) under laboratory conditions simulating the ISM conditions at temperature $T=10$ K (<https://cutt.ly/3SYT169>). A spontaneous(!) formation of relatively short peptides (less than 10-11 monomeric units) was found. The polymerization of amino acids under energetic processing (e.g. heat, pressure, or UV irradiation) is known to occur. Therefore, a further increase in chain length can be expected in natural environments.

Moreover, by adding other species instead of a proton to the α -carbon atom of amino ketene (nearest to the functional group) during the polymerization, a variety of different peptide chains can be formed. Furthermore, chemical and photochemical modifications of glycine residues in peptides into other amino acid residues were also demonstrated in many works. Thus, the glycine peptides observed in our experiments can be converted into different proteins.

- (c) These findings fit nicely with the proposed mechanism for the formation of proteins (or at least short peptides). The mechanism is not chemical, and no radiation is needed since the generalized Josephson radiation would provide the energy of the AA-AA bond, and the formation rate does not vanish at ultralow temperatures.

13.3.4 How did lipids, small organic molecules, and DNA and RNA polymers emerge?

There is a temptation to say that after the emergence of proto-cell membrane and peptides, the rest was history. This is not so simple.

- (a) The formation of the proto-cell membrane could occur spontaneously if lipids are available. Lipids however have C-C bonds with bond energy 3.47 eV and $\text{C}=\text{C}$ bonds with energy 6.28 eV. These energies are in the UV range.

- (b) Also the energies of valence bonds associated with DNA, RNA, and also other basic biomolecules are in this range. The freezing of the chemistry at ultralow temperatures does not allow the generation of these bonds since the metabolic machinery provided by ATP molecules is not present. Simple organic molecules and even amino-acids are however detected in the interstellar medium. It seems that life-as-nothing-but-chemistry dogma must be wrong.
- (c) The Josephson radiation associated with proto-cell membrane with an energy scale of .1 eV could help in the formation of peptides but cannot help in the more general case. Could the splitting of a hydrogen bond provide the metabolic energy quantum of .5 eV in the absence of ATP machinery? The formation of water involving O-H bonds and their dynamics at temperatures of few K do not sound plausible unless one leaves the framework of the standard chemistry.

Metabolic machinery involves a lot of control and the standardization made possible by the metabolic energy quantum. This involves a lot of control. What could have served as a controller and energy source for bond formation at ultralow temperatures of few Kelvin and in the absence of the complex metabolic machinery based on ATP. In the TGD Universe, MB carrying dark matter is the answer to the question.

- (a) The existence of B_{end} was originally deduced by Blackman [J31] and other researchers. They found that ELF em fields had quantum-like effects on the vertebrate brain. These effects could be understood in terms of cyclotron transitions in the "endogenous" magnetic field $B_{end} \simeq 2B_E/5$ if the value h_{eff} of Planck constant was much larger than h , $h_{eff}/h \sim 10^{13}$ was required in order to scale the energy of 10 Hz photon to that of a visible photon with frequency 10^{14} Hz.
- (b) The large value of h_{eff} suggests its identification as gravitational Planck constant $\hbar_{eff} = \hbar_{gr} = GMm/v_0$ given by Nottale's hypothesis [E2]. M denotes here Earth's mass and m the mass of the charged particle. This predicts that cyclotron frequencies in B_{end} correspond to dark photon energies in the visible and UV range. Most remarkably, the energies do not depend on the mass m of charged particles. This realizes the Equivalence Principle.
- (c) Visible-UV energy range is associated also with biophotons [I166, I107] discussed from TGD view point in [K17, K26]. This motivates the identification of biophotons as decay products of dark photons or possibly even dark N-photons resulting in $h_{eff} \rightarrow h$ transition. Dark photons or N-photons in this energy. Note that the Nottale hypothesis and the notion of a monopole magnetic flux tube make sense only in the TGD Universe.
- (d) $h_{eff}/h_0 = n$ is identifiable as a dimension of extension of rationals in number theoretic vision about TGD. n serves as a kind of IQ [L55, L56]. MB with $h_{eff} = h_{gr}$ corresponds to a rather high level of number theoretic complexity assignable to the MB of Earth as a quantum system. MB has a long scale of quantum coherence - even of the order of the scale of Earth - and is by its high "IQ" the natural "boss" and controls the dynamics of the ordinary biomatter. The molecular transitions induced by the transformations of dark cyclotron (3N-)photons would serve as a natural control tool of MB. The cyclotron condensates at MB can provide quantized metabolic currencies in the absence of ATP machinery.
- (e) MB could generate already at few Kelvin temperatures various biologically important molecules by providing the metabolic energy for the formation of various valence bonds, such as carbon and peptide bonds and make possible the formation of lipids, DNA and RNA molecules and their polymers and also other basic organic molecule. Josephson radiation would in turn make possible the generation of proteins. Gravitation would be a key player in living systems and play an especially important role in the very early stage. The chemistry at ultralow temperatures would provide a direct experimental handle to the biophysics associated with MB.

13.3.5 What can one say about pre-tRNA?

What could be the prebiotic counterpart of tRNA?

- (a) DtRNA should have a molecular counterpart. The simplest guess is that it corresponds to an RNA type codon appearing in tRNA but somehow differing from it. Pre-tRNA could simply be the (AAC-H)3' end of the acceptor stem with AAC replaced with XYZ, where ZYZ denotes the codon part of tRNA. The addition of a hydrogen atom would relate pre-tRNA codon to ordinary RNA codon.
- (b) The bond energy for the pre-tRNA-AA pair as the energy of the ester bond would be about .5 eV, which corresponds to the metabolic energy quantum. Energy is therefore required to "charge" pre-tRNA. This requires metabolic energy and in the absence of ATP machinery, the energy should come from its predecessor. What prebiotic metabolism could be, will be discussed in the next section.
- (c) If this step works, the polymerization of tRNAs involving the transformation of the ester bond of pre-tRNA-AA to AA-AA peptide bond can occur spontaneously since the peptide bond has bond energy of order .1 eV. This would give rise to polypeptides. This process would be like a translation process for RNA but without an RNA template and therefore the outcome would be random. Also the RNA polymerization in this manner can be considered, now however the RNA-RNA valence bond has considerably higher bond energy.
- (d) If DRNA-RNA sequences are formed, they might be transformed to AA sequences by pre-translation process using pre-tRNA and resonance mechanism pairing DRNAs and dark counterparts of pre-tRNA-AA pairs. This would define the pre-translation process.

13.3.6 What could the prebiotic metabolic machinery be?

Metabolic machinery should have a prebiotic counterpart and have energy about .5 eV as metabolic energy quantum.

- (a) Could the splitting of a hydrogen bond with bond energy about .5 eV provide the energy needed in the formation of pre-tRNA-AA ester bond? IR photons are most effective in causing Pollack effect in water: could also they induce pre-tRNA-AA pairing? Both options would require the presence of water. In principle, the proposed mechanism could lead to a generation of water molecules (the energy of O-H bond is 4.81 eV) already at temperatures of few Kelvin.
- (b) Could MB somehow provide the metabolic energy quantum? Gravitational flux tubes are in a central role in the TGD inspired quantum biology. In [L119] it was observed that the gravitational binding energy of a nucleon in the gravitational field of Earth is .67 eV. This is somewhat larger than the metabolic energy quantum. A dark proton at a distance of about $.34R_E$, R_E Earth radius, from the surface of Earth has gravitational binding energy of .5 eV.

The bond energy of the hydrogen bond is .5 eV. Could it correspond to the reduction of the gravitational binding energy due to the delocalization of a dark proton to a gravitational flux tube? Could the hydrogen bond become dark gravitational U-shaped monopole flux tube with $h_{eff} = h_{gr}$ so that the proton of the ordinary hydrogen bond would become gravitationally dark? the size scale of Earth would define the length scale of this flux tube. The flux tube could however still connect the same atoms.

The transformation $h_{gr} \rightarrow h$ induces a dramatic shortening of the U-shaped gravitational flux tube loop and the gravitationally dark proton at the gravitational flux tube of MB transforms to an ordinary proton. This localization has interpretation as falling

of the proton to the surface of Earth. Could the liberated energy have an interpretation as a ametabolic energy quantum?

For a dark variant of hydrogen bond a gravitational flux tube between atoms should form a very long loop at which the gravitationally dark proton would reside. This kind of picture about dark flux tubes associated with gauge interactions has been suggested earlier. For instance, color flux tubes assignable to nuclear protons could extend to distances of the order of atomic size.

- (c) Phosphate is electronegative and forms hydrogen bonds. Phosphate ionization could be interpreted as a formation of a dark hydrogen bond. This would explain why phosphate ions have such a central role in metabolism. Effective ionization serves as the signature of the delocalization. Also other electronegative ions could play the role of phosphate and arsenite has done this in some bacterial systems (<https://cutt.ly/ZS1fznG>).

The pre-biotic counterpart of metabolic machinery should have involved phosphate ions or some other electronegative ions forming dark hydrogen bonds.

- (d) Also the valence electrons of valence bonds can become dark by the lengthening of the valence bond to a U-shaped gravitational flux loop. For electrons the gravitational binding energy at height $.34R_E$ is about .25 meV and .5 meV for their Cooper pairs. Note that .3 meV corresponds to the energy of photons in the microwave background.

Could this define a second metabolic energy quantum important in scales by a factor $m_p/m_e \sim 2^{11}$ longer than nanoscale about 1 nm assignable to DNA. This is the length scale of the cell nucleus, microtubules and axons. Intriguingly, the minimal fluctuations of membrane potentials correspond to the so-called miniature end plate potentials .4 mV (<https://cutt.ly/HSJIn76>).

- (e) A gravitational valence bond, connecting a metal atom with an atom with an opposite valence, would lead to effective ionization of the metal atom. For instance, biologically important bosonic ions such as Ca^{++} , Mg^{++} , Fe^{++} and Zn^{++} associated with their oxides could correspond to effective ions like this.

The signature would be a pairing with a neutral oxygen atom by a gravitational valence bond. I have introduced the notion of dark ion to explain the findings of Blackman [J31] and others and dark ion could correspond to this kind of pair. The original variant of the model assumed that the entire ion is dark, the later version assumed that the valence electron of free atom is dark, and the model consider here assumes that the valence bond is dark.

- (f) The effective ionization requires energy ΔE to compensate the increment of the gravitational potential energy given by $\Delta E = (\langle V_{gr}(R) \rangle - V_{gr}(R_E))$. Here $E_{gr}(R)$ is gravitational potential energy proton or electron, and R_E denotes the radius of Earth, and R is the distance of the point of flux tube from the center of Earth.

This estimate neglects the kinetic energy of the dark particle at the flux loop. This assumption is not consistent with the localization near the top of the loop so that the estimate can serve only as a rough order of magnitude estimate.

- (g) The maximal value for ΔE for electron Cooper pair (dark Cooper pair is at infinite distance) corresponds to $V_{gr}(R_E) = .36$ meV to be compared with the energy scale .3 meV defined by the temperature of 3 K microwave background and to the value .4 meV of the miniature potential. This suggests that, in the case of the electron, the reduction of kinetic energy contributes more than 10 per cent to the ΔE .

For a single dark proton one has $V_{gr}(R_E) \simeq .34$ eV, which is below the nominal value of the metabolic energy currency about .5 eV. If a single dark proton is involved, the reduction kinetic energy should contribute at least 32 per cent to ΔE .

For a dark proton Cooper pair, one has the maximal value of $\Delta E = .68$ eV somewhat above the metabolic energy quantum. These findings support the idea that both proton and electron Cooper pairs give rise to metabolic energy quanta. The challenge would be to understand the mechanism for the formation of proton Cooper pairs.

- (h) The transformation of electrons and protons between ordinary and gravitationally dark states would be a key process of metabolism and biocatalysis. This conforms with the fact that proton and electron exchanges play a key role in biology. For instance, phosphorylation means that the receiving molecule gains phosphate, which can form gravitationally a dark hydrogen bond so that the system becomes metabolically active. This would correspond to the activation in bio-catalysis.

DNA base pairs are connected by 2 (A-T) or 3 (G-C) hydrogen bonds. If these strands can appear as dark gravitational strands, the maximum of 2 (3) metabolic quanta could be liberated in A-T (G-C) pairs via a transformation to ordinary hydrogen bonds. Could this serve as a yet-unidentified source of metabolic energy in the replication and transcription?

- (i) In the same way, in a redox reaction, the electron donor is oxidized and the electron receiver is reduced. Reduced molecule gains the ability to have a gravitationally dark electron, and therefore becomes metabolically active in the electronic sense. Redox reaction would be the electronic counterpart for phosphorylation.

13.3.7 Could the metabolism of cilia and flagella rely on gravitationally dark electrons?

The recent work in TGD has led to considerable progress in the understanding of metabolism [L127] already discussed in the section 14.2.5. The TGD based view about metabolism involves in an essential way quantum gravity.

The observation is that the gravitational binding energy of dark protons at Bohr orbits in Earth's gravitational field for $h_{eff} = h_{gr} = Gmm/v_0$ [E2] [K36, K37, K38, K39, K88] [L119, L104] can correspond to metabolic energy quantum in good approximation. The proposal is that the transformation of protons of hydrogen bonds possible for electronegative atoms and occurring at least for phosphate generates gravitationally dark protons. Their transformation would liberate metabolic energy quantum.

The prediction is that besides gravitationally dark protons also similar electrons define a metabolic energy currency relating to standard metabolic currency like cent to dollar. It is proposed that the electronic metabolic currency can be applied to the purely understood metabolism of cilia and flagella (<https://cutt.ly/WDkYZzx>). I attach the proposal below almost as such.

According to [?] (<https://cutt.ly/EDkW2bu>) the recent measurements in sea urchin sperm (length $\sim 50 \mu\text{m}$ long, diameter $0.2 \mu\text{m}$) show that the energy consumed per flagellar beat corresponds to $\simeq 2 \times 10^5$ ATP molecules. There is no GTP inside cilium as in the case of axonal MTs (<https://cutt.ly/5DkYGB2>). It is difficult to understand how ATP machinery could provide the metabolic energy feed.

This motivates the question about whether local ciliary metabolism could rely on the transformation of valence electrons of some biologically important ions to dark electrons at the gravitational MB and vice versa? The reduction of h_{gr} for electrons would provide the metabolic energy related by a factor $m_e/m_p \simeq 2^{-11}$ to the ordinary. According [?], about 4×10^8 gravitationally dark electrons would transform to ordinary ones in a single stroke of cilium.

Electronic metabolic energy quantum would relate like cent to dollar and make possible a more refined metabolism with fine tuning. Electronic metabolism could also be an essential part of ordinary metabolism.

Consider now the idea more quantitatively.

- (a) What could be the electronic analog of ATP machinery. All biologically important ions can be considered as effective ions with some valence electrons at gravitational MB. In particular, the bosonic ions Ca^{++} , Mg^{++} , Fe^{++} and Zn^{++} could have Bose-Einstein condensates of gravitationally dark Cooper pairs at the gravitational MB.

Ca^{++} waves play a key role in cellular biology, Fe^{++} is essential for oxygen based metabolism, and Mg^{++} and Zn^{++} are important in bio-catalysis: for instance, ATP must bind to Mg ions in order to become active.

- (b) What could be the mechanism transforming valence electrons to dark electrons? This should happen for positively charged biologically important ions, in particular for the bosonic ions Ca^{++} , Mg^{++} , Fe^{++} and Zn^{++} . The consumption of metabolic energy would correspond to a de-ionization of dark ion Ca^{++} and this might make it possible to test the proposal. For instance, Ca^{++} could accompany ciliary waves.

Where could the energy for ionization come from?

- (a) This question is also encountered in the chemistry of electrolytes [L51]. It is very difficult to understand how the external electromagnetic potentials, which give rise to extremely weak electric fields in atomic scales, could lead to ionization. The acceleration of electrons in the electric field along dark flux tubes involves very small dissipation and can easily give rise to electron energies making ionization possible.
- (b) MTs have a longitudinal electric field which by the generalization of Maxwell's equations to many-sheeted space-time (in stationary situation potential difference is same for paths along different space-time sheets) gives rise to an electric field along the magnetic flux tubes. These flux tubes need not be gravitational.

By darkness, the dissipation rate is low. Could the acceleration along flux tubes, in particular MT flux tubes, lead to the ionization? Could the electret property of linear biomolecules quite generally serve for the purpose of generating electronic metabolic energy storages in this way?

- (c) Assuming opposite charges $\pm Z_{MT}$ at the ends of dark magnetic flux tube associated with the MT, one obtains a rough estimate. The length of the cilium is $L \leq .5 \times 10^{-4}$ m and its radius is $R \sim 2 \times 10^{-7}$ m. The estimate for the energy gained by a unit charge e as it travels through the ciliary MT is $E \sim Z_{MT}e^2L/R^2 \simeq Z_{MT} \times 2.85$ eV. The valence electron energy for atomic number Z with principal quantum number n (giving the row of the Periodic Table) is $E \simeq (Z/n)^2 \times 13.6$ eV. The ionization condition would be $Z_{MT} \geq (Z^2/n^2) \times 13.6/2.85$. For the double ionization in the case of Ca^{++} with $Z = 20$ and $n = 3$ this would give $Z_{MT} \geq 212$.

13.3.8 Quantum gravitation in TGD inspired quantum biology

The theory of Penrose and Hameroff [J80] assigns to microtubules quantum gravity in Planck length scale. In the TGD Universe, one does just the opposite. The hierarchy of effective Planck constants assigns to quantum gravitation quantum coherence scale even in the scales of astrophysical objects.

The notion of gravitational magnetic body

The proposed picture allows us to reconsider a long-standing question relating to the notion of MB with an onion-like layered structure. What could this sentence mean quantitatively?

- (a) The 4-surfaces X^4 with 1-D CP_2 projection and 3-D M^4 projection having 2-D membrane as E^3 projection are good candidates for various membrane objects in TGD Universe [L121]. The E^3 projection is not a minimal surface although X^4 is, and this possible if the 1-D CP_2 projection is dynamical. The flux tubes of MB should be assignable to kind of membrane-like surface.
- (b) The gravitational MB could be a layered structure containing the Bohr orbits with Bohr radii $r_n \propto n^2$ of particles in the gravitational field of Earth. Particles with different masses would concentrate at the same orbits. One would have the shell structure of

the ordinary atom. This notion generalizes also to other interactions and for them the values of h_{eff} would be much smaller.

- (c) Flux sheets with a cylindrical rotational symmetry containing the orbits can be considered. These surfaces should be realized as preferred extremals of the action and should be minimal surfaces in $H = M^4 \times CP_2$. As closed surfaces they cannot define minimal surfaces of the Euclidean 3-space E^3 . Indeed, soap bubbles are not minimal surfaces but require a constant pressure difference between interior and exterior. The analog of pressure difference would be non-trivial and dynamic 1-D projection of 4-D surface to CP_2 [L121]. The liberation of metabolic energy quantum would be analogous to a transition of hydrogen atom to a lower energy state.

Cell membrane, nerve pulse and quantum gravitation

This picture makes it possible to formulate a more precise view about the model of cell membrane as a generalized Josephson junction for which the generalized Josephson energy for charge Ze is the sum $E_J = ZeV + \Delta E_c$ of ordinary Josephson energy ZeV and difference ΔE_c of dark cyclotron energies for the flux tubes at the two sides of the cell membrane having in general different strengths of magnetic field.

The model requires large h_{eff} in order that Josephson frequencies can correspond to frequencies in the EEG range. This justifies the assumption that dark ions have $h_{eff} = h_{gr}$. The ionization would be effective and caused by the transformation of protons of hydrogen bonds and valence electrons to dark charge carriers at the gravitational flux tubes.

The physical meaning of the criticality against the generation of nerve pulse for a critical membrane potential $eV_{cr} \simeq .05$ eV has remained open.

- (a) Since voltage gives rise to negative potential energy, it seems clear that there must be positive contribution to the energy and this could come from the reduction ΔE_{gr} of the gravitational potential energy due to the positive *resp.* effective ionization of atoms of metal atoms *resp.* electronegative atoms with hydrogen bonds.

The reduction of the gravitational potential energy for electrons is fraction m_e/m_p from that for protons so that protonic contribution should dominate in the reduction of gravitational potential energy if dark electrons and protons correspond to the same shell of gravitational atom. The first guess is that the energy shell and thus the distance from the Earth's surface is the same.

The parametrization of the reduction of the gravitational energy per atom and for the difference ΔE_c of cyclotron energies should in the standard picture correspond to a thermo-dynamical formulation using chemical potentials to fix the ion concentrations. The water has very special thermodynamic properties in the range between freezing and boiling points and anomalies are largest near physiological temperatures. This would be due to the presence of dark hydrogen bonds, which supports the view that the number of dark protons and electrons depends on temperature.

- (b) In the first approximation the negative Coulombic interaction energy for the cell membrane is given by $E_{Coul} = -Q_{tot}eV = -\sum_i N_i(out)Z_i eV$, where N_i is the number effective ions with charge $Z_i e$. The contribution of positive charges is negative since V corresponds to a negative net charge for the cell. The situation is stable for $|E_{Coul}| \geq |E_{Coul,cr}| = N_p \Delta E_{gr}$. The system becomes critical at $Q_{tot}eV_{cr} = N_p \Delta E_{gr}$. The value of the critical potential energy is given by $eV_{cr} = N_p \Delta E_{gr} / Q_{tot}$ and is roughly constant for a given neuron. This suggests that the ratio N_p / Q_{tot} characterizes the cell.

Neurons and ordinary cells could differ in that ordinary cells are either subcritical or so overcritical that nerve pulses do not occur. Subcriticality looks the more plausible option. The emergence of the nervous system would mean the discovery of quantum criticality as a control tool of MB.

- (c) In the generation of the nerve pulse the dark protons and electrons become ordinary ones in the reduction $h_{gr} \rightarrow h_{eff} \leq h_{gr}$ for them and the membrane potential changes sign. In ZEO this transition could correspond to BSFR inducing time reversal and change of membrane potential. The second BSFR would bring back the original situation and membrane potential would return to the over-critical value.

Microtubules and quantum gravitation

In the TGD Universe quantum gravitation would be associated with the cell membrane, in particular neuronal membrane. Quantum gravitation has been speculatively assigned with microtubules (MTs) rather than cellular or neuronal membranes. What is the situation in TGD?

- (a) Axonal MTss are highly critical systems, which continually change their lengths. The surface of MTs has one GDP per tubulin dimer and the ends of MT has GTPs so that there is a constant negative charge per unit length. The number of GTPs is larger at the second end so that there is an electric field along MT.
- (b) $GTP \leftrightarrow GDP$ process accompanies the variation of the length of the MT. The transformation of the protons assignable to the phosphate hydrogen bonds to gravitationally dark protons could be an essential element of the MT dynamics. The periods of increasing/decreasing MT length could be initiated by BSFR and would correspond to different arrows of time. The effective ionization affects the effective charge of the axonal interior and therefore of membrane potential. This suggests a strong correlation with the variation of axonal MT lengths and nerve pulse propagation.

The propagation of nerve pulse through the myelinated sections of the axons, where ion transfer with cell exterior is not possible, is a mystery in the standard model. Without axonal MTs the nerve pulse propagation would not be possible. This could allow us to understand why various neuronal diseases involve a reduced MT stability [J53] (<https://cutt.ly/4DaF6qc>).

13.4 Appendix: Tables of basic types of 3-chords for icosahedral harmonies

13.4.1 Icosahedral harmonies as Hamiltonian cycles

One can find the list of Hamiltonian cycles at <http://tinyurl.com/yacgzm9x>. The edge $\{1, 2\}$ is fixed and cycles are oriented so that there are 1024 of them. All of them are relevant from the point of music interpretation and the change of orientation corresponds to major-minor duality, albeit not in the simplest sense. Note that this duality does not affect the characteristics listed above.

The general following general results hold true as one can learn at <http://tinyurl.com/pmghcwd>. One can classify the cycles using their symmetries which can correspond to isometries of icosahedron leaving them fixed or to a reflection taking the vertex n at the cycle to vertex $12 - n$. This symmetry is not same as change of orientation which is purely internal operation and cannot change the cycle.

One can even find images of the cycles possessing symmetries at <http://tinyurl.com/y8ek7ak8> and deduce the triplets n and p characterizing them by visual inspection. Also one can write explicitly the 3-chords defined by the three kinds of faces. I have deduced the triplets n and the 3-chords defining the harmony by the inspection of the images. “Bio-harmony” (4, 8, 8) forced by the model of extended genetic code involving also the 21st and 22nd amino-acids is of special interest. The classes of cycles with symmetries 6-fold rotational symmetry and two distinct reflection symmetries realize it.

$$\begin{aligned}
CEG \equiv C, \quad CD\sharp G \equiv Cm, \quad CD\sharp F\sharp \equiv C^o, \quad CEG\sharp \equiv Caug, \\
CFG \equiv C4, \quad CF\sharp G \equiv C4_+, \quad CGG\sharp \equiv C6_-, \quad CGA \equiv C6, \\
CGB\flat \equiv C7, \quad CGB \equiv Cmaj7, \quad CGC\sharp \equiv C9_-, \quad CGD \equiv C9.
\end{aligned} \tag{13.4.1}$$

Table 13.1: Notation of chords inspired by popular music notations.

Before continuing some terminology and notation is in order. Take C as the major key. Submediant or relative minor corresponds to Am , subdominant (sharp or flat) to F major (F) or Fminor (Fm), dominant to G . The notation for chords is such that quints correspond to subsequent notes in the chord. For 1-quint chords this means that first two notes define the quint.

Table 13.1 summarizes the notation inspired by the popular music notation. The basic difference is that the third is in most cases excluded so that the emotional character of the chord is not fixed.

Besides these notions it is convenient to introduce additional notations for various dissonant chords appearing as 0-quint chords.

$$\begin{aligned}
CC\sharp D \equiv Cex1, \quad CC\sharp D\sharp \equiv Cex2, \quad CDD\sharp \equiv Cex3, \quad CDE \equiv Cex4, \\
CD\sharp E \equiv Cex5, \quad CC\sharp E \equiv Cex6, \quad CDF\sharp \equiv Cex7, \quad CDG\sharp \equiv Cex8.
\end{aligned} \tag{13.4.2}$$

Clearly, the sets $\{ex1\}$, $\{ex2, ex3\}$, $\{ex4, ex5, ex6\}$, $\{ex7\}$, $\{ex8\}$, corresponds to the span of 2, 3, 4, 6, 8 half notes for the chord.

The following summarizes the results. Note that $Cex7$ can be seen as part of $D7$ chord.

- (a) There are 6 collections of cycles without any symmetries containing 48 cycles each: these 48 cycle are mutually isometric so that one can say that there 6 different harmonies.
- (b) There is a collection with 6-fold rotational symmetry, $48/6=8$ examples. $n = (2, 12, 6)$. The chords of this scale define 6-note scale involving only total steps. CDF and its 6 translates by integer number of steps define 6 1-quint chords. $CE\flat G$ (Cm) and its 6 translates (they obviously correspond to the 6-fold rotational symmetry) define also 6 1-quint chords. The reflection transforms these series to those defined by $G\flat B\flat G$ and its translate and by FAC (F major) and its translates. Impressionists like Debussy used 6-note scale of this kind. Half-octave shift is an exact symmetry. 1-chords lack the third so that one cannot assign to 3-chords any emotional quality. The extension to 4-chord can however bring either “happy” or “sad” quality. Clearly, these harmonies have “jazzy” character.

0-quint chords are $Faug \equiv FAC\sharp$ and $Gaug \equiv GHD\sharp$ are transformed to each other by both half-octave shift and inversion.

- (c) There are 2 collections with 2 distinct reflectional symmetries with $12=48/4$ representatives in each. Half-octave scaling is a symmetry of both these scales as one might guess.

The first cycle (see **Fig. ??**) has $n = (0, 16, 4)$ so that there are no 0-quint chords which in general are dissonant. Second cycle (see **Fig. ??**) realizes $n = (4, 8, 8)$ bio-harmony and deserves some comments. It will be discussed in detail later.

- i. The 8 2-quint chords consist of $B\flat FG \equiv B\flat 9$, $C9$, $F9$, $G9$ and their half-octave scalings. Clearly, the simple four-note scale appears here.

- ii. Using the popular notion introduced earlier, 1-quint chords consist of two 4-plets $Dmaj7$, $E9_-$, $A7$, $A6$ and $G\sharp maj7$, $B\flat 9_-$, $D\sharp 7$, $D\sharp 6$ related by half-octave shift. The harmony contains no “simple” major or minor chord and only the extension to tetrahedral harmony can provide them. The same is true for the second bio-harmony.
 - iii. The 4 0-quint chords are $Cex3 \equiv CDD\sharp$ and $Eex2 \equiv EFG$ and their half-octave scalings $F\sharp ex3 \equiv F\sharp G\sharp A$ and $B\flat ex2 \equiv B\flat BC\sharp G$.
- (d) There are 3 collections with Z_2 rotational symmetry with $48/2 = 24$ representatives in each. The triplets n are $(0, 16, 4)$ (see **Fig. ??**), $(2, 12, 6)$ (see **Fig. ??**), and $(4, 8, 8)$ (see **Fig. ??**).

All these harmonies are symmetric with respect to half-octave shift (tritonus), which obviously corresponds to the Z_2 rotation. Tritonus would not have been tolerated by catholic church! This symmetry characterizes all 3 harmonies. Basic 3-chords do not contain pure minor and major chords. The reflection of the scale does not leave the collection of chords invariant but it is not clear whether this corresponds only to a change of scale, probably not.

Consider the $(4, 8, 8)$ case (see **Fig. ??**).

- i. The 8 2-quint chords appear as four-plet $H9$, $C\sharp 9$, $D\sharp 9$, $F9$ and its half octave shift (tritonus interval) acting as a symmetry of the harmony. 2-quint chords are always of type X^9 (note that the third is missing) but also 1-quint chord can be of form X^9 as explicit construction of chords demonstrates: I have denoted these 1-quint chords by symbol $X4$ (CDG is obviously equivalent with CDG).
- ii. Using the popular music notation introduced earlier, the 8 1-quint chords are $D7$, $Amaj7$, $A4_+$, $E7$ and their half-octave shifts $G\sharp 7$, $D\sharp 7$, $D\sharp 4_+$, $B\flat 7$.

No major and minor chords are included and only the extension to tetra-icosahedral harmony can provide them and also break the symmetry giving rise to well-defined key.

- (e) The four 0-quint chords appear in two types. $D\sharp ex2 \equiv D\sharp EF\sharp$ and its half-octave shift $Aex2 \equiv AB\flat C$ plus $Hex3 \equiv HC\sharp G$ and its half-octave shift $Fex3 \equiv FGC\sharp$. According to usual thinking these chords involve dissonances. This dissonance character is a rather general phenomenon for the harmonic loners and classical views about harmony would exclude them as asocial cases! In the case of maximally symmetric harmony the loners are diminished chords and thus not so dissonant. In some cases there are no 0-quint chords.

There are 5 collections of 20 chords with Z_2 reflection symmetry (see **Figs. ??, ??, ??, ??, ??**). The integer triplets n are $(2, 12, 6)$, $(2, 12, 6)$, $(4, 10, 6)$, $(2, 12, 6)$, $(2, 12, 6)$. Bio-harmony has a representative also in this class (see **Fig. ??**). The half-octave scaling symmetry is broken for these harmonies.

Some comments $(4, 8, 8)$ case are in order (see **Fig. ??**).

- (a) 2-quint chords appear as reflection related multiplets $C9$, $D9$, $H\sharp 9$, $D\sharp 9$ and $C\sharp 9$, $H9$, $F9$, $B\flat 9$.
- (b) 1-quint chords appear as symmetry related mutiplets G , $D7$, $Amaj7$, $E7$ and $C\sharp m$, $F\sharp 6$, $H6_-$, $E6$. Key G major and $C\sharp$ minor would be natural looking keys even without tetrahedral extension. For the mirror image $B\flat$ minor and E major would be the natural looking keys. For extension E major would be the key.

To sum up, half octave shift is a symmetry of all harmonies expected those having only Z_2 reflection symmetry, and fails thus also for the corresponding bio-harmonies. The tables below give list for the three types of 3-chords for the 11 harmonies possessing symmetries. A

(n_0, n_1, n_2)	0-chords	1-chords	2-chords
(2, 12, 6)	$(Faug, Gaug)$	$(Cm, Dm, Em, F\sharp m, G\sharp m, Bbm),$ $(F6, G6, A6, B6, C\sharp 6, D\sharp 6).$	$(C9, D9, E9, F\sharp 9, G\sharp 9, Bb9).$

Table 13.2: Table gives various types of 3-chords for harmonies with Z_6 rotational symmetry. Note that half-octave shift is an exact symmetry. Note that $G^{aug} = CEG\sharp, F^{aug}$ act as bridges between the groups related by half octave shift. The chords have been arranged so that they form orbits of Z_6 . “Amino-acid chords” correspond to preferred chords at the orbits.

(n_0, n_1, n_2)	0-chords	1-chords	2-chords
(0, 16, 4)		$(D7, D6, G\sharp 7, G\sharp 6),$ $(G4+, A9-, C\sharp 4+, D\sharp 9-),$ $(Emaj7, Gmaj7, Bbmaj7, C\sharp maj7),$ $(C9-, A9-, F\sharp 9-, D\sharp 9-).$	$(Bb9, B9, E9, F9).$
(4, 8, 8)	$(Cex3, Eex2, F\sharp ex3, Bbex2).$	$(Dmaj7, E9-, A7, A6),$ $(G\sharp maj7, Bb9-, D\sharp 7, D\sharp 6).$	$(Bb9, F9, C9, G9).$ $(E9, B9, F\sharp 9, C\sharp 9).$

Table 13.3: Table gives various types of 3-chords for the two harmonies with $Z_4 = Z_2^{rot} \times Z_2^{refl}$ symmetry. 4-plets represent the orbits. First cycle has no harmonic loners. Second cycle gives rise to bio-harmony (4, 8, 8) for which 0-quint chords are dissonant. Both cycles have Z_2 rotation symmetry acting as a vertical reflection symmetry in figures and realized also as half-octave shift so that 4-plets contains chords and their half-octave shifts. The genuine reflection symmetry acts as a horizontal reflection symmetry in figures. The cycles correspond to figures ??, ??

3-chord with n quints is called n -quint chord. The harmonies are labelled by integer triplets (n_0, n_1, n_2) , n_i gives the number of n -quint chords.

The reversal of the orientation for the cycle induces the transformation $C \leftrightarrow C, F\sharp \leftrightarrow F\sharp, H \leftrightarrow C\sharp, F \leftrightarrow G, D \leftrightarrow Bb, E \leftrightarrow G\sharp, A \leftrightarrow D\sharp$ and produces a new scale with minor type chords mapped to major type chords and vice versa.

The standard notation of chords used in popular music is used. One must however remember that all 3-chords except those which are simple majors or minors lack the third so that their emotional tone remains uncharacterized. For instance, $C6$ does could be replaced with $Cm6$ and $G7$ with $Gm7$. The reader can check the chords by direct inspection of the figures. The convention used is that vertex number 1 in Hamiltonian cycle corresponds to C note.

13.4.2 Tables for the 3-chords of icosahedral harmonies

The following tables give the 3-chords of the icosahedral harmonies.

13.4.3 Illustrations of icosahedral Hamiltonian cycles with symmetries

The figures below illustrate the Hamiltonian cycles involved. Quite generally, the Z_n symmetry acts by a shift by $12/n$ quints along the cycle and the orbits of chords consist of at most n chords of same type as the reader is encouraged to verify.

(n_0, n_1, n_2)	0-chords	1-chords	2-chords
(0, 16, 4)		$(Em, Bbm), (Cm, F\sharp m),$ $(G6, C\sharp6), (A6, D\sharp6),$ $(D4+, G\sharp4+), (B4+, F4+),$ $(Cmaj7, F\sharp maj7), (G6-, C\sharp6-).$	$(D9, G\sharp9),$ $(E9, B\flat9).$
(2, 12, 6)	$(Aex4, D\sharp ex2).$	$(Am, D\sharp m), (G9-, C\sharp9-),$ $(C4, F\sharp4), (E4+, B\flat4+),$ $(Dmaj7, G\sharp maj7),$ $(Bmaj7, Fmaj7).$	$(C9, F\sharp9),$ $(A9, D\sharp9),$ $(D9, G\sharp9).$
(4, 8, 8)	$(Aex2, Hex8, D\sharp ex2, Fex8).$	$(D7, G\sharp7), (Amaj7, D\sharp maj7),$ $(A4+, D\sharp4+), (E7, B\flat7).$	$(G9, C\sharp9), (A9, D\sharp9),$ $(B9, F9), (E9, B\flat9).$

Table 13.4: Table gives various types of 3-chords for harmonies with Z_2 rotation symmetry acting as half-octave shift. The doublets represent 2-chord orbits. The cycles correspond to figures ??, ??, and ??.

(n_0, n_1, n_2)	0-chords	1-chords	2-chords
(2, 12, 6)	$(F\sharp ex3, Hex4),$	$(Am, D\sharp), (A6, D\sharp7),$ $(D7, B\flat6), (G6-, Fmaj7),$ $(D4+, B\flat9-), (E9-, G\sharp4+),$	$(C9, F9), (B9, F\sharp9),$ $(E9, C\sharp9).$
(2, 12, 6)	$(Dex4, Hex4).$	$(F, Fm), (C6-, B\flat maj7),$ $(D7, G\sharp6), (Gmaj7, D\sharp6-),$ $(C\sharp4-, A4+), (E4+, F\sharp6).$	$(C9, D\sharp9),$ $(D\sharp9, C\sharp9),$ $(E9, B9).$
(4, 8, 8)	$(Fex1, D\sharp ex3, G\sharp ex1, Aex2).$	$(E7, E6), (Amaj7, B9-),$ $(G, C\sharp m), (D7, F\sharp6).$	$(D9, B9), (C9, C\sharp9),$ $(F9, G\sharp9), (D\sharp9, B\flat9).$
(2, 12, 6)	$(Hex3, Eex7).$	$(D7, G\sharp6), (G, D\sharp m),$ $(F, Fm), (C6-, B\flat maj7),$ $(A9-, C\sharp4+), (E7, F\sharp6).$	$(C9, D\sharp9),$ $(D9, C\sharp9),$ $(E9, B9).$
(2, 12, 6)	$(F\sharp ex2, Fex3).$	$(F, Bbm), (C7, G\sharp6),$ $(Amaj7, B9-), (E6, E7),$ $(G, C\sharp m), (D7, B6).$	$(B\flat9, D\sharp9),$ $(C9, C\sharp9),$ $(D9, H9).$

Table 13.5: Table gives various types of 3-chords for harmonies with single reflection symmetry. The cycles correspond to figures ??, ??, ??, ??, ??.

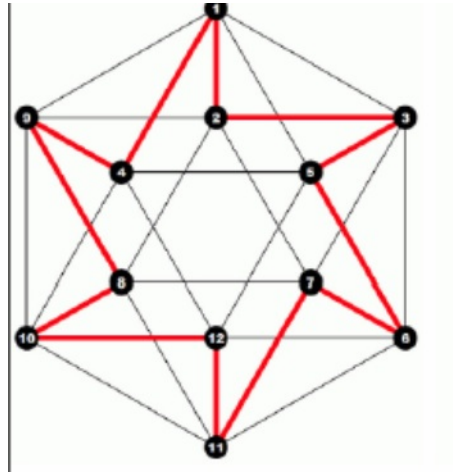


Figure 13.1: $(n_0, n_1, n_2) = (2, 12, 6)$ Hamiltonian cycle with 6-fold rotation symmetry acting shifts generated by a shift of 2 quints.

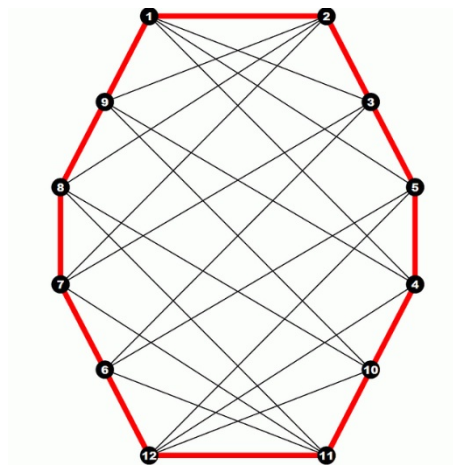


Figure 13.2: $(n_0, n_1, n_2) = (0, 16, 4)$ Hamiltonian cycle with 4 reflection symmetries generated by reflections in vertical and horizontal directions.

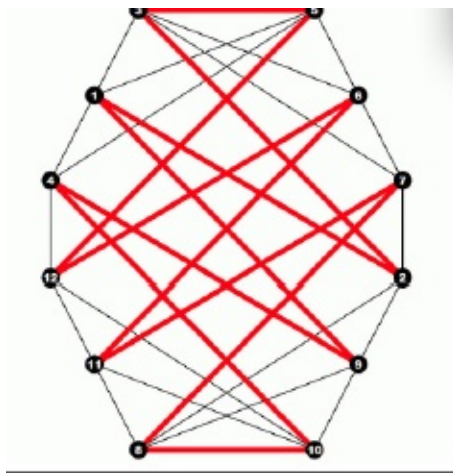


Figure 13.3: $(n_0, n_1, n_2) = (4, 8, 8)$ Hamiltonian cycle with 4 reflection symmetries.

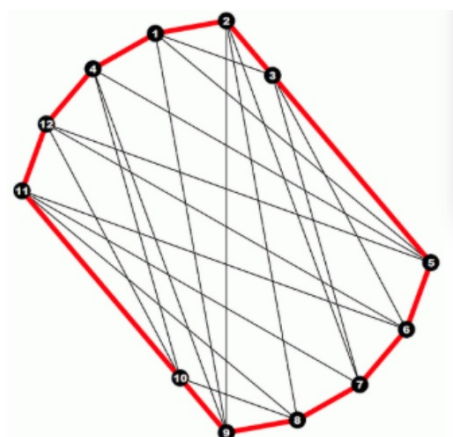


Figure 13.4: $(n_0, n_1, n_2) = (0, 16, 4)$ Hamiltonian cycle with 2-fold rotational symmetry realized as 6-quint shift along the cycle.

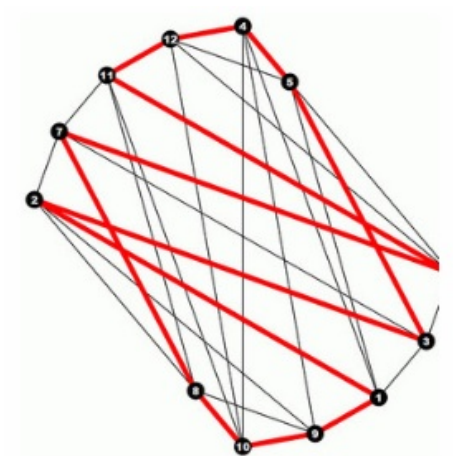


Figure 13.5: $(n_0, n_1, n_2) = (2, 12, 6)$ Hamiltonian cycle with 2-fold rotation symmetry.

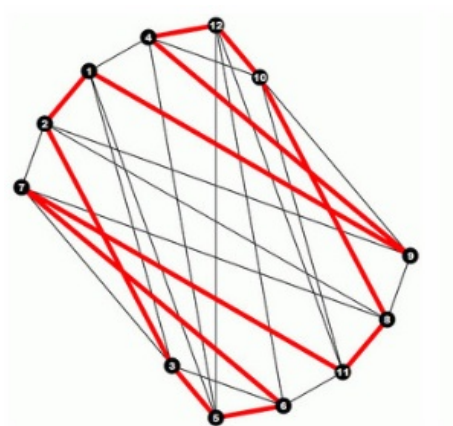


Figure 13.6: $(n_0, n_1, n_2) = (4, 8, 8)$ Hamiltonian cycle with 2-fold rotation symmetry.

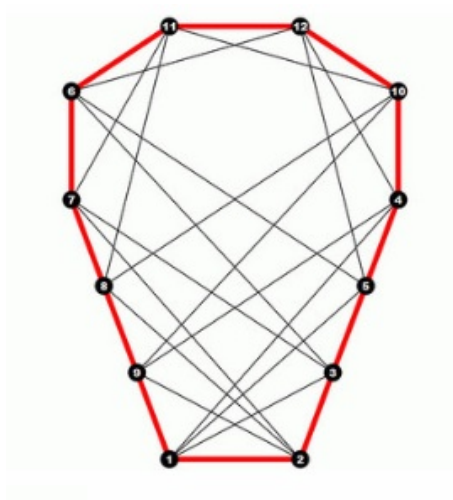


Figure 13.7: $(n_0, n_1, n_2) = (2, 12, 6)$ Hamiltonian cycle with 2-fold reflection symmetry realized as horizontal reflection

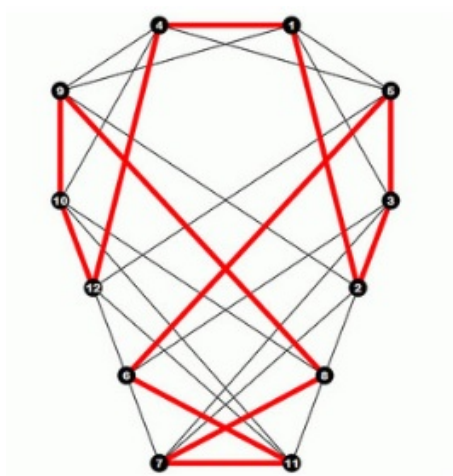


Figure 13.8: $(n_0, n_1, n_2) = (2, 12, 6)$ Hamiltonian cycle with 2-fold reflection symmetry.

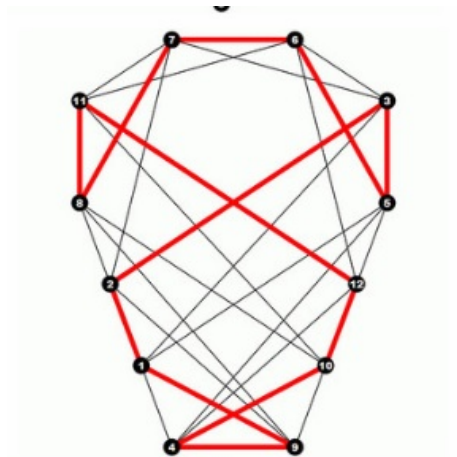


Figure 13.9: $(n_0, n_1, n_2) = (4, 8, 8)$ Hamiltonian cycle with 2-fold reflection symmetry.

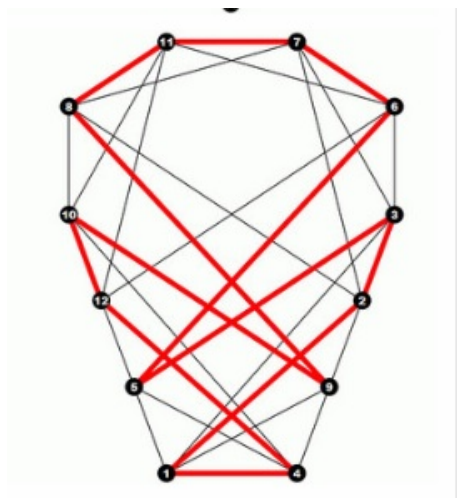


Figure 13.10: $(n_0, n_1, n_2) = (2, 12, 6)$ Hamiltonian cycle with 2-fold reflection symmetry.

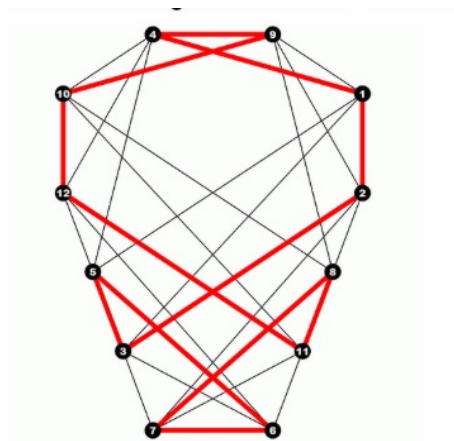


Figure 13.11: $(n_0, n_1, n_2) = (2, 12, 6)$ Hamiltonian cycle with 2-fold reflection symmetry.

Chapter 14

Quantum gravitation and quantum biology in TGD Universe

14.1 Introduction

This article summarizes the recent understanding about the biological role of quantum gravitation in the TGD Universe.

14.1.1 The role of quantum gravitation in TGD inspired quantum biology

In this article several new ideas related to quantum gravitation in the sense of TGD are introduced. The notion of quantum gravitational magnetic body (MB) leads to a considerably sharpening of the existing picture and provides an improved understanding of the real nature and role of biologically important dark ions.

- (a) The notion of magnetic body (MB) carrying ordinary matter as phases with effective Planck constant $\hbar_{eff} = n\hbar_0$ suggests that MB acts as a master and ordinary matter is at the bottom of the slaving hierarchy. There are reasons to believe that gravitational flux tubes with very large value $\hbar_{eff} = \hbar_{gr}GMm/v_0$ of gravitational Planck constant [E2] [?, K88] [L119, L104] are of special importance and correspond to the very high level in the hierarchy and to scales of order Earth scale. One could say that quantum gravity would transform chemistry to biochemistry and distinguish between the chemistries in *vivo* and in *vitro*.
- (b) Gravitational MB, which consists of very long loop-like flux tubes with gravitational Planck constant introduced by Nottale [E2] explains the findings of Blackman and others [J31], is of special interest and assumed to play a key role in metabolism. Gravitationally dark protons would be associated with very long gravitationally dark hydrogen bonds (HBs). Due to delocalization of the proton, hydrogen would be effectively negatively ionized.

Gravitationally dark electrons or their Cooper pairs would in turn accompany gravitationally dark valence bonds (VBs) connecting metal atoms or their Cooper pairs with molecules of opposite valence (hydrogen peroxide H_2O_2). Also the metal atom is effectively ionized. This provides a more accurate view of dark metal ions assumed to play a central role in the TGD inspired quantum biology.

A correct order of magnitude estimate for the upper bound metabolic energy quantum as the energy liberated as a dark proton HB becomes ordinary is obtained. A more

precise model predicts correctly the nominal value of metabolic energy quantum for proton triplets which appear also in the generation of ATP. For triplets of electron Cooper pairs, the same mechanism predicts an upper bound of the electronic metabolic energy quantum, which corresponds to the so-called miniature potential. This raises the question whether the letters of genetic code could be realized by the 4 states of electron Cooper pairs and whether the Posner molecule could realize it.

- (c) One obtains a correct order of magnitude estimate for the upper bound metabolic energy quantum as the energy liberated as a dark proton HB becomes ordinary. A more precise model predicts correctly the nominal value of metabolic energy quantum for proton triplets which appear also in the generation of ATP. For triplets of electron Cooper pairs, the same mechanism predicts an upper bound of the electronic metabolic energy quantum, which corresponds to the so-called miniature potential of about .4 meV. This raises the question whether the letters of genetic code could be realized by the 4 states of electron Cooper pairs and whether the Posner molecule could realize it.
- (d) Also the gravitational MB of Sun could be involved and the prediction is that the energy range for the metabolic energy quanta corresponds to the range of visible energies so that photosynthesis could use photon energy to kick dark protons and dark electrons to the gravitational MBs of Earth and Sun to serve as a metabolic energy storage. Remarkably, the photosphere has temperature in thermal energy in the range $[.4, .6]$ eV which corresponds to metabolic energy quantum.
- (e) This picture about dark HB leads to a rather detailed model of the role of phosphate in metabolism. Electronic metabolism could solve the problem due the lack of ATP machinery inside cilium and near it. Spikes having the same scale as miniature potentials observed in neurons could also appear in plants. For the recently observed spike sequences in fungi, the voltage spike has an amplitude with order of magnitude roughly consistent with the electronic metabolic energy quantum [I52].
- (f) A detailed model for the pairing of DNA and dark DNA (DDNA) emerges and forces to modify the earlier model somewhat. The HBs associated with base pairs could transform to gravitational HBs either by reconnecting directly with gravitational flux tubes or by double reconnection with gravitational HBs assignable to phosphate of the DNA nucleotide. This process could make possible the splitting of these HBs occurring in the replication and transcription. The very weak dependence of DNA properties on various salt concentrations in vivo is in sharp contrast to the strong dependence in vitro. This difference can be understood.

14.1.2 TGD based view of nerve pulse

The proposed model starts from the existing TGD based view about nerve pulse but the new quantum gravitational view about metabolism leads to a sharpening of the understanding of the role of biologically important ions in nerve pulse conduction.

- (a) TGD leads to a quantum view [K96, K44, K98] [L100, L104] about cell membrane as a generalized Josephson junction consisting of Josephson junctions defined by membrane proteins and to the proposal that soliton sequences analogous to a sequence of rotating penduli with phase difference increasing along the axon, define the resting states of the membrane.

Nerve pulse would be induced by a perturbation transforming rotation to vibration locally, this propagating perturbation could be called pre-nerve pulse. Also the variant, in which rotation is replaced by oscillation - one would have an "oscillon" sequence - so that perturbation would generate a propagating soliton, can be considered. Note however that one cannot associate a definite rotation direction to an oscillon. The criticality against the generation of nerve pulse has remained poorly understood.

- (b) TGD also leads to a speculative view about the function of nerve pulse patterns. Usually they are considered to serve as signals inside the brain. An alternative view [L100] is that they make signalling by dark photons propagating along flux tubes parallel to axons or massless extremals parallel to flux tubes. The synaptic vesicles containing neurotransmitters would temporarily fuse the pre- and postsynaptic neurons and also connect flux tubes to a single flux tube acting as a wave guide so that dark photon messages could propagate.

This would make possible very rapid communications between the brain (or even MB) and sensory organs and the building of standardized sensory inputs and standardized mental images by using a virtual sensory input from the brain or MB. Essentially pattern completion and recognition would be in question. Sensory perception would be an artwork rather than photograph. Nerve pulses could also send sensory information from the neuronal membrane to MB.

- (c) Could the meridian system serve as a predecessor of the nervous system such that gap junctions could define permanent flux tube connections between cells? In the nervous system the connections would be dynamical and used only when needed.

The quantum gravitational view about metabolism leads to a modification of the views of nerve pulse conduction.

- (a) In the earlier quantum model, the cell membrane acts as a generalized Josephson junction for biologically important dark metal ions. The ground state of the axon corresponds to a soliton sequence, which has a sequence of rotating gravitational pendulums as a mechanical analog. Action potential corresponds to a soliton (or several solitons) with opposite direction of rotation.
- (b) In the updated model, the dark ions are identified as gravitationally dark effective ions with gravitationally delocalized Cooper pairs of dark electrons. Also gravitationally dark protons assignable to HBs are involved. The delocalization of protons and possibly also electrons to gravitational bonds provides a concrete realization for the variation of the membrane potential in the myelinated portions of the axons, where ion currents are not possible.
- (c) One unsolved problem of the Hodgkin-Huxley model is the conduction of neural signals through the myelinated portions of the axons, where nerve pulse is impossible. The formation of dark hydrogen- and valence bonds induces an effective ionization, which takes membrane potential below the critical value for the generation of nerve pulse, which is generated in unmyelinated portions.
- (d) Microtubules (MTs) are believed to be important in many quantum biological approaches and deserve a separate discussion. In the TGD framework, the quantum antenna hypothesis was one of the first proposals in this direction [K83]. Their precise role has however remained unclear hitherto.

MTs appear in several variants. Cilia and flagella, which are analogous to axons, contain stationary MTs whereas axonal MTs are highly dynamical. The critical dynamics of axonal MTs involves a variation of MT length relying on $\text{GDP} \rightarrow \text{GTP}$ transition, which involves the change of HB to gravitational HB and vice versa changing the local membrane potential. Therefore MT dynamics makes possible the propagation of the perturbation of the membrane potential in unmyelinated portions of the axon. The effect of anesthetics can be understood in terms of a reduced density of HBs preventing the formation of gravitational HBs so that MTs and the axonal potential freeze.

The findings about multicellular animals of Prakash et al [I165, I163, I164], which have no nervous system but behave as if they had brain, provide valuable hints in attempts to

understand the role of MTs. A model of the pre-neural system, based on the gravitational MB and the predicted electronic metabolic energy quantum, is developed in order to explain how these animals control their cilia. Cilia have no mitochondria inside them or in their vicinity and the electronic metabolism could replace the usual metabolism.

14.2 Update of the general ideas of TGD inspired quantum biology

In the sequel I develop a TGD based interpretation of findings in the conceptualization provided by TGD. I will proceed from general to specific and use cilia as example to illustrate the general ideas.

14.2.1 Basic motion patterns as analogs of Bohr orbits

Prakash *et al* identify a small number of basic motion patterns of cilium [I165, I163, I164]. More complex motion patterns of cell can be constructed as combinations of from these using simple rules.

For a general mechanical deterministic system 3-D initial values for generalized positions and velocities determine the time evolution and huge number of different time evolutions are possible. A chaotic behavior is much more plausible than the highly organized behavior analogous to that for organisms possessing central nervous system.

These findings resonate with the general TGD based classical description of classical physics in terms of the topology of space-time surfaces $X^4 \subset M^4 \times CP_2$ as preferred extremals (PEs) of the basic action principle [L116].

- (a) In the TGD framework, space-time as a 4-surface in $H = M^4 \times CP_2$ is topologically non-trivial in all scales and various shapes of matter, usually assigned to matter in almost flat and topologically trivial space-time of general relativity, correspond directly to the topology of the space-time surface.
- (b) From the general coordinate invariance, space-time surface is a preferred extremal (PE) of a general coordinate invariance action principle, which realizes holography in the sense that 3-surface as boundary values determines almost completely the 4-surface, which is therefore analogous to Bohr orbit. There is however a small failure of determinism localizable at the singularities where minimal surface property fails. PEs are minimal surfaces with singularities analogous to frames of ordinary soap films [L121].
- (c) The space-time counterparts of all biological and neurological functions (this includes the development of mechanical and electromagnetic patterns such as nerve pulse patterns) correspond to PEs. PEs are also analogous to the modules of computer programs. A small failure of quantum determinism corresponds to a selection of sub-modules in branching points and correspond to the non-determinism of soap films with frames.
- (d) Zero energy ontology of TGD which predicts that quantum states of a system are superpositions of space-time surfaces as preferred extremals (PEs) of action. "Small" state function reductions (SSFRs) as the TGD counterparts of "weak" measurements would select between different variants of space-time surface with same singularities (frames of soap film) and BSFRs would correspond to big changes.

The small repertoire of different motion patterns would correspond to a collection of PEs. From these patterns for cilia more complex patterns would be constructed for the motion patterns for a cell would emerge. From the patterns for cell motion the patterns for a multi-cellular system would emerge. There would be a hierarchy of complexity reducing to a hierarchy of extensions of rationals at fundamental level.

14.2.2 Quantum criticality

Also cilium and a ciliary system could be near quantum criticality and this could be essential for the changes of the state of the motion of cilia.

The motions of microtubules inside cilia force the bending of cilia. The beating waves with frequency 4-10 Hz propagating along cilia and having constant phase along a 1-D section curve of the 2-D transverse section of transversal plane of cilium are known to induce the motions of a single cilium. In multicilium system these motions are in the same phase and induce coherent motion

When the height h , the orientation of cilium, and the beating frequency f are near criticality, a BSFR would occur and induce a sudden change in the motion of cilium. The criticality of the beating frequency could mean resonance between the microtubuli inside cilium and BSFR would induce the shortening of the flux tube pair connecting them. This would induce the bending of the flux tube.

The presence of 3 parameters suggests a catastrophe theoretic description using Thom's catastrophe theory based on a butterfly catastrophe with 3 control parameters.

14.2.3 Excitable systems in zero energy ontology

In the TGD framework, the idea that excitable systems as systems making "big" state function reductions (BSFRs) as counterparts of ordinary SFRs in macroscopic spatial and temporal scales is suggestive. In BSFR the arrow of time changes and after BSFR the dissipative development occurs in reverse time direction and looks to the observer with the standard arrow of time like self-organization and generation of patterns. This BSFR is followed by second BSFR re-establishing the original arrow of time.

In quantum critical systems, the value of h_{eff} would be fluctuating and the change of h_{eff} could happen in BSFR. The dynamics of microtubules (MTs) could be quantum critical since it involves continual growth and decay of MTs, which would correspond to a sequence of BSFRs. During mitosis (cell replication) the expansion and contraction of MTs involving change of h_{eff} and BSFR would play a key role.

Bio-catalysis is another example [L173]. The reactants would be brought near each other by a contraction of the flux tube pairs connecting them. The flux tubes pairs would be formed by a reconnection of U-shaped flux tubes of reactants acting as tentacles if there is cyclotron frequency resonance (the thicknesses of the U-shape flux tubes are identicals). The BSFR involving a contraction due to the reduction of h_{eff} . After reaction h_{eff} could reduce to its original value in second BSFR.

14.2.4 The notions of magnetic and electric body

The notions of magnetic body and electric body are central in TGD inspired quantum biology but their precise definition has been far from clear. The intuitive notion is that MB consists of U-shaped monopole flux tubes extending from the system considered and serving as kinds of tentacles. These flux tubes for two systems can reconnect and form a pair of flux tubes connecting the system if the cyclotron frequencies of the tubes are the same so that cyclotron resonance becomes possible.

MB is characterized by the value of the effective Planck constant $h_{eff} = nh_0$, where n corresponds to the dimension of the extension of rationals assignable to the space-time regions by $M^8 - H$ duality [L90, L91]. One can assign MB to flux tubes mediating electromagnetic, gravitational and even weak and color interactions, and the scale of MB correlates with the screening length of these interactions. For gravitation there is no screening and the values of $h_{eff} = h_{gr}$ can be very large. The large value of $h_{gr} = GMm/v_0$ [E2] implies that the dark cyclotron radiation in the EEG range would correspond to visible and UV energies.

In the TGD framework magnetic body (MB) would serve as the controlling agent receiving sensory information as a frequency modulated dark Josephson radiation and controlling the

cell by using dark cyclotron radiation coming as pulses corresponding to resonant receipt of Josephson radiation.

What could be the electric counterpart of the magnetic body? Magnetic flux tubes can also be dynamical and locally orthogonal helical magnetic and electric fields are possible. Electric body should be something different. Various membrane-like structures populate the Universe and they could correspond to electric bodies.

- (a) The 4-surfaces X^4 with 1-D CP_2 projection and 3-D M^4 projection having 2-D membrane as E^3 projection are good candidates for various membrane objects in TGD Universe [L121]. The E^3 projection is not a minimal surface although X^4 is, and this possible if the 1-D CP_2 projection is dynamical. The flux tubes of MB should be assignable to kind of membrane-like surface.
- (b) The gravitational MB, if it exist, could be a layered structure containing the Bohr orbits with Bohr radii $r_n \propto n^2$ of particles in the gravitational field of Earth. Particles with different masses would concentrate at the same orbits. One would have the shell structure of the ordinary atom. This notion generalizes also to other interactions and for them the values of h_{eff} would be much smaller.
- (c) Flux sheets with a cylindrical rotational symmetry containing the orbits can be considered. These surfaces should be realized as preferred extremals of the action and should be minimal surfaces in $H = M^4 \times CP_2$. As closed surfaces they cannot define minimal surfaces of the Euclidean 3-space E^3 . Indeed, soap bubbles are not minimal surfaces but require a constant pressure difference between interior and exterior.

The analog of the pressure difference would be non-trivial and dynamic 1-D projection of 4-D surface to CP_2 [L121]. The liberation of metabolic energy quantum would be analogous to a transition of hydrogen atom to a lower energy state.

14.2.5 The notion of gravitational magnetic body

The notion of gravitational MB turns out to be crucial for the understanding of the role of quantum gravitation in TGD inspired quantum biology.

Gravitational magnetic body as a controlling agent and the prediction of two metabolic energy quanta

In the TGD framework magnetic body (MB) would serve as the controlling agent receiving sensory information as a frequency modulated dark Josephson radiation and controlling the cell by using dark cyclotron radiation coming as pulses corresponding to resonant receipt of Josephson radiation.

The large value of $h_{eff} = h_{gr} = GMm/v_0$ [E2] implies that the dark cyclotron radiation in the EEG range would correspond to visible and UV energies.

The intuitive notion is that MB consists of U-shaped monopole flux tubes extending from the system considered and serving as kinds of tentacles. These flux tubes for two systems can reconnect and form a pair of flux tubes connecting the system if the cyclotron frequencies of the tubes are the same so that cyclotron resonance becomes possible.

In [L127], the question of what the notion of gravitational MB does mean, was considered.

- (a) The dark flux tube would be "gravitational" with $h_{eff} = h_{gr}$. Gravitational flux tubes carry Kähler monopole flux but no gravitational flux. This would be in conflict with the irrotational nature of gravitational field at Newtonian limit. The monopole flux could however have interpretation as gravimagnetic flux. The attribute "gravitational" is motivated by the assumption that one has $h_{eff} = h_{gr}$. The ordinary, short, MB reconnects atoms A and B.

Gravitational flux tubes have lengths, which can be of the order of Earth size scale and the radii of gravitational Bohr orbits define a natural scale form them. Gravitational flux tubes are closed flux tubes with the shape of a highly flattened triangle with a long side in the vertical direction and having length of order Earth size scale and short side of order interatomic distance for the atoms A and B connected by HB.

This inspires a rather concrete vision about the structure of gravitational MB as a forest of gravitational flux tubes analogous to trees. This applies also to non- gravitational flux tubes with smaller values of h_{eff} . One would have a full magnetic flora. The larger the value of h_{eff} , the more complex the magnetic plant would be. MB would be like a fractally scaled-up variant of the ordinary forest. Reconnections would make possible transfer of gravitational flux tubes so that also magnetic fauna would be present.

- (b) One obtains gravitationally dark hydrogen bond (HB) from an ordinary HB when a HB from A to B reconnects with a pre-existing long gravitational flux tube to create a very long gravitational flux tube from A to B. Proton is delocalized as a gravitationally dark proton and its gravitational potential energy is reduced so that the flux tube stores metabolic energy. In the reverse process a reverse reconnection takes place and this metabolic energy is liberated.

The reconnection process requires a feed of energy: for instance solar radiation can provide it in photosynthesis. A similar description applies in the case of valence bonds (VBs). Note that the transformation of an ordinary, short HB to a long gravitational HB is not a realistic option since this would require a lot of energy since magnetic energy would be created.

- (c) The elongated gravitational flux tubes could correspond to either hydrogen bonds (HBs) or valence bonds (VBs). The loop-like bond could connect nearby atoms just like the ordinary bond. The delocalization of the charge to the flux tube leads to an effectively ionized donor atom.
- (d) All values of h_{eff} are possible. For electromagnetic flux tubes the values of h_{eff}/h are not very large. This picture leads to a view about hydrogen and VBs as bonds having $h_{eff}/h > 1$ [L51]. Also gravitational variants of hydrogen and VBs are possible. In this case, the proton or electron would be vertically delocalized in the Earth scale so that the donor atom would be effectively ionized. For instance, a phosphate ion could be an effective ion having a gravitational hydrogen bond with the hydrogen of a water molecule.
- (e) A gravitational VB, connecting a metal atom with an atom with an opposite valence, would lead to effective ionization of the metal atom. For instance, biologically important bosonic ions such as Ca^{++} , Mg^{++} , Fe^{++} and Zn^{++} associated with their oxides could correspond to effective ions like this.

The signature would be a pairing with a neutral oxygen atom by a gravitational VB. I have introduced the notion of dark ion to explain the findings of Blackman [J31] and others and dark ion could correspond to this kind of pair. Note that the original variant of the model assumed that the entire ion is dark, the later version assumed that the valence electron of free atom is dark, and the model considered here assumes that darkness is a property of bond.

- (f) The effective ionization requires energy ΔE to compensate the increment of the gravitational potential energy given by $\Delta E_{gr} = (\langle V_{gr}(R) \rangle - V_{gr}(R_E))$. Here $E_{gr}(R)$ is gravitational potential energy proton or electron, and R_E denotes the radius of Earth, and R is the distance of the point of flux tube from the center of Earth.

Classical energy conservation suggests that the value of vertical kinetic energy at the surface of Earth is equal to the increment of the gravitational potential energy at the top of the loop. From energy conservation one can estimate the metabolic energy quantum as a liberated kinetic energy in the normal direction equal to the increase of gravitational potential energy. Hence the naive guess could be correct.

- (g) The maximal value for ΔE_{max} for electron Cooper pair (dark Cooper pair is at infinite distance) corresponds to $V_{gr}(R_E) = .36$ meV to be compared with the energy scale .3 meV defined by the temperature of 3 K microwave background and to the value .4 meV of the miniature potential. This suggests that, in the case of the electron, the reduction of kinetic energy contributes more than 10 per cent to the ΔE .

For a single dark proton one has $V_{gr}(R_E) \simeq .34$ eV, which is below the nominal value of the metabolic energy currency about .5 eV.

- (h) The condition that the end of the vertical gravitational loop travels along a stationary orbit parallel to the plane of rotation of Earth such that the normal velocity of the dark particle vanishes at the top, implies for the tangential velocity v_T the condition $v_T^2 = \omega^2 R^2 = GM/R$ allowing to determine the radius of the orbit as

$$\frac{R}{R_E} = \left(\frac{r_{s,E} c^2}{2\omega^2}\right)^{1/3} \times \frac{1}{R_E} \simeq 3.1 \quad .$$

The change of the gravitational potential energy in the transition to an ordinary proton would be $\Delta E = \Delta E_{gr} = .68 \times V_{gr}(R_E)$, which would give $\Delta E = .18$ eV. In the dark genetic codons hydrogen bonds appear as triplets. 3 dark protons would give metabolic energy quantum .55 eV. Interestingly, a translocation of 3 protons fuels synthesis of ATP!

- (i) For an electron Cooper pair the upper bound for the metabolic energy quantum would be $\Delta E_{max} = .33$ meV, which is below the miniature potential .4 meV. For the stationary flux tubes one obtains $\Delta E = .17$ meV. Later the evidence for the 'spikes' in fungi [I52] discovered by Adamatsky will be discussed: their amplitude is reported to be in the range .03-2.1 meV which contains ΔE .

For an electron Cooper pair triplet one would have $\Delta E = .51$ meV consistent with the miniature potential .4 meV. Should one take this seriously? Could also dark electron Cooper pairs organize into triplets like dark protons would do and in this manner define dark genetic code? TGD predicts that genetic code is universal: could also dark electron Cooper pairs define a dark variant of the genetic code?

Posner molecules $[(\text{PO}_4)^{-3}]_6\text{Ca}_9^{+2}$, to be discussed in the sequel, consists of 3 $[(\text{PO}_4)^{-3}]_2\text{Ca}_3^{+2}$ acting as a basic unit. This unit could contain 3 electronic Cooper pairs with electronic metabolic energy quantum $\Delta E = .51$ meV. In principle, Cooper pairs can have spin 1 or spin state giving 4 states altogether. Could these states define letters of a dark genetic codon so that the basic unit would define a genetic codon and Posner molecule could correspond to a triplet of genetic codons?

The TGD view about formation of bound states as Galois singlets [L141] allows us to consider this possibility. For an extension of extensions of ... the Galois group would decompose to a hierarchy of Galois groups acting as normal subgroups. Codons as triplets would be Z_3 singlets in both the ordinary and the electronic genetic code. Genes would correspond to larger Galois groups decomposing to normal subgroups. Codon doublets of DNA double strands would be Z_2 singlets and triplets of triplets of Posner molecules would be Z_3 singlets.

- (j) A proper treatment of the situation would require Schrödinger equation for the dark particle at the flux loop. The situation is analogous to a quantum model of the fountain effect of super-fluidity discussed in [K36, K37, K38, ?] in a situation when the gravitational potential can be linearized (WKB approximation).

One can consider Schrödinger equation for h_{gr} idealizing the loop with a 1-D box with gravitational potential GMm/r . The Schrödinger equation reduces in dimensionless variable $u = (m/\hbar_{gr})z = 2\beta_0(z/r_s)$, $r_s = 2GM$ to

$$\left(-\frac{\partial_u^2}{2} - \frac{\beta_0}{u}\right)\Psi = \frac{E}{m}\Psi \equiv \epsilon\Psi \quad .$$

A possible condition is that the vertical derivative $\partial_z \Psi$ vanishes at the top of the loop. The metabolic energy quantum equals $(GM/R_E - \epsilon(v))m$ and is quantized. The height of the loop could be quantized using the condition that the loop end is stationary with respect to Earth.

If this speculative picture makes sense, quantum gravitation would play a key role in metabolism and genetic code.

- (a) The transformation of electrons and protons between ordinary and gravitationally dark states would be a key process of metabolism and biocatalysis. This conforms with the fact that proton and electron exchanges play a key role in biology. For instance, phosphorylation means that the receiving molecule gains phosphate, which can form gravitationally a dark hydrogen bond so that the system becomes metabolically active. This would correspond to the activation in bio-catalysis.
- (b) In the same way, in a redox reaction, the electron donor is oxidized and the electron receiver is reduced. Reduced molecule gains the ability to have a gravitationally dark electron, and therefore becomes metabolically active in the electronic sense. Redox reaction would be the electronic counterpart for phosphorylation.

The role of solar gravitational field in metabolism

Also the gravitational field of the Sun could be important in metabolism.

- (a) At the distance of 1 AU of the Earth, the counterpart of single proton metabolic energy quantum .18 eV would be 2.6 eV, which is in the visible range. For a proton triplet, the energy would be 7.8 eV and in the UV range. This quantum would be realized as a long flux tube directed away from the Sun in the plane of the Earth's orbit and orthogonal to the orbit.
- (b) Could the visible solar radiation kick protons to solar gravitational flux tubes and the radiation of photosphere having energy range [4,.6] eV to the gravitational flux tubes of Earth in photosynthesis? Could the solar part of dark gravitational energy for protons be transformed to ordinary metabolic quanta in metabolism? Note that the feed of the solar radiation energy to flux tubes suggests a modification of the proposed simple model involving only gravitation.
- (c) This picture would be true for all Sun-like stars and for planets at the distance of Earth and supports the view that Earth-like planets for Sun-like stars are favourable for life.

Metabolic energy depends on gravitational environment

According to the proposed simple model, bio-chemistry would strongly depend on the local gravitational environment.

- (a) For an object with mass M and radius R , the estimated maximal gravitational metabolic energy quantum E_{max} is scaled up by factor is scaled up by a factor $z = (M/M_E) \times (R_E/R)$. The values of z for Mercury, Venus, Mars, and Moon are (.2,.14,.86,.04). For Venus, which is called the sister planet of Earth, z is not too far from unity.

For the stationary orbits around an object with radius R_1 , mass M_1 , and rotation frequency ω_1 the ratio $\Delta E_1/\Delta E_E$ of metabolic energy quantum to that for Earth satisfies the scaling formula

$$\frac{\Delta E_1}{\Delta E_E} = \frac{R_E}{R_1} \times (1 - x_1 x_2 x_3) \quad , \quad x_1 = \left(\frac{M_1}{M_E}\right)^{1/3} \text{ per,} \quad x_2 = \times \left(\frac{\omega_E}{\omega_1}\right)^{2/3} \quad , \quad x_3 = \frac{R_E}{R_1}$$

- (b) In the case of the Moon, E_{max} would be by a factor $z = R_E/R_{Moon} = .017$ smaller than at the surface of Earth. The stationarity condition would require a flux tube orbit radius smaller than the Moon radius. In the case of Venus, the sidereal rotation period is -243.0 days (retrograde): also now the orbit of stationary radius would be smaller than the radius of Venus. This suggests that only the metabolism utilizing the solar gravitational field photosynthesis is possible and would be essentially the same as at the surface of Earth.
- (c) In the case of Mars one has $\omega_1/\omega_E \simeq 1$, $M_1/M_E = .1$, $R_1/R_E = .533$. This gives $\Delta E = .24\Delta E_E$, which for the proton Cooper pair would give .13 eV. Could the solar gravitational field save the space traveller in case of Moon and Mars? The largest distance from Earth is about 1.7 AU and at this distance the maximal value of the solar metabolic energy quantum is scaled down by a factor .59.

Jupiter's (<https://cutt.ly/CF8bteR>) moon Europa (<https://cutt.ly/HF8buAp>) is one of the most promising candidates for a seat of life since it contains water in the form of ice. Is quantum gravitational metabolism based on the solar and Jovian gravitational fields consistent with Earth-like metabolism?

For the Jupiter's gravitational field, the gravitational potential energy at the surface of Europa is $V_{gr} = GM_J m/R_{Eu}$ and defines the maximal value ΔE_{max} of the metabolic energy quantum for a flux loop defining dark gravitational HB oriented radially outwards along A line connecting Europa and Jupiter. The mean distance d_{Eu} from Jupiter is $d_{Eu} = 105.3 \times R_E$ to be compared with the radius $R_J = 10.97 R_E$ of Jupiter. The mass of Jupiter is $M_J = 317.8 M_E$. This gives $\Delta E_{max, Eu}/\Delta E_{max, E} = V_{gr, J}/V_{gr, E} = (M_J/M_E) \times (R_E/d_{Eu}) \simeq 3.0$.

For a single gravitationally dark proton, the maximal metabolic energy gain would be .99 eV, which is twice the metabolic energy quantum. Standard metabolic energy quantum .5 eV corresponds to a radially oriented loop with height $h = d_{Eu}$. If a proton triplet defines the metabolic energy quantum, one would have $h = (1/5)R_{Eu}$.

Solar radiation should provide metabolic energy. The average distance d_J of Jupiter from Sun varies between 5.0AU and 5.4AU so that the gravitational metabolic energy quantum has upper bound $\Delta E_{gr, Sun, J} \leq \Delta E_{gr, Sun, E}/5 \simeq .5$ eV, which corresponds to metabolic energy quantum. Photosphere produces IR radiation with energies in the range .4-.6 eV. Therefore Europa seems to satisfy the conditions from quantum gravitational metabolism.

Just for fun, one can also look at the situation at the surface of Sun.

- (a) At the surface of the Sun, one has $z \simeq 3.0 \times 10^2$ and the metabolic energy quantum .55 eV for dark proton triplet scales to $\Delta E_{Sun} \sim .16$ keV: this is below the threshold for the nuclear fusion and below the temperature of $\sim .23$ keV of the solar corona. An interesting question is whether the X-ray radiation arriving to Earth could have some, perhaps even biological, function. TGD indeed predicts that nuclei have excitations in the keV range [L3].
- (b) For a dark electron Cooper at solar surface, the upper bound is .08 eV. The temperature of the photosphere corresponds to photon energy of .4-.6 eV, which corresponds to the metabolic energy quantum associated with the Earth's gravitational flux tubes. Could the IR thermal radiation from the photosphere serve as a metabolic energy source?

How does this model relate to the TGD inspired model for Cambrian Explosion [L68] [L120]?

- (a) The TGD explanation for the sudden emergence of new phyla in Cambrian Explosion is that the radius of Earth doubled in CE in rather short time. If the end of flux tube moves along stationary orbit, the scaling formula gives for the metabolic energy quantum before the transition for the dark proton triplet the value $\Delta E_{gr} = .38 \times \Delta E_{gr, max}$, which gives $\Delta E_{gr} = .3$ eV. This is considerably smaller than .55 eV.

- (b) According to Stephen Gould (see the book "Wonderful life" about Burgess Shale Fauna [?]), a large number of the phyla suddenly disappeared. Could this mean that they were not able to adapt to the transition increasing the value of the metabolic energy quantum? On the other hand, a rapid evolution started. Could this relate to the increased sizes of the protonic and electronic metabolic energy quanta? Solar metabolic energy quanta would not have changed.

Do Moon travellers survive in TGD Universe?

3 dark protons give the nominal value of metabolic quantum. If the naive estimates are taken seriously, terrestrial life might not be possible on Mars and Moon. Humans have however successfully visited the Moon and it is not clear whether the solar gravitational field comes to rescue.

Rather than giving up the idea, it is better to ask what goes wrong with the simplest model. The quasiclassical estimate assumes that the dark charge at the top and bottom of the gravitational flux tube has the same kinetic energy. If the kinetic energy at the top is higher, the value of the metabolic energy quantum increases. This inspires the question whether the reduction of the kinetic energy in the metabolic energy quantum can be neglected.

- (a) The simplest model for the particle at gravitational VB is as a particle in a box with kinetic energies given by $E_n = n^2 \hbar_{eff}^2 / mL^2$, L the length of the loop. If L scales like \hbar_{eff} , the kinetic energy does not depend on \hbar_{eff} . Therefore the scale of kinetic contribution can be estimated in a molecular length scale.
- (b) Could the system adapt to a reduction of the maximal gravitational potential at the surface of the Moon, Mars, or Venus by increasing the average value of n in the superposition of the standing waves having maximum at the top of the valence loop? The system would adapt by increasing the localization of the dark charge at the top of the loop. The reduction of the bond length would mean reduction of the superposition to $n = 0$ wave so that the kinetic energy would be indeed liberated.

Dark gravitational bonds and high energy phosphate bond

How could the somewhat mysterious high energy phosphate bond (HEPB) associated with di-phosphates (DP) and tri-phosphates (TP) relate to the gravitationally dark hydrogen bonds (HBs)?

- (a) HEPB (<https://cutt.ly/2FcLFJY>) is identified as the bond $\dots - O - \dots$ connecting two P atoms in ATP or ADP (<https://cutt.ly/HFcLKyk>). Hydrolysis involves also one H_2O molecule. The $-O - P$ bond splits inducing the splitting of ATP to ADP and P_1 . One cannot assign HEPBs to the monophosphates (MPs) associated with DNA so that the splitting of the O-P bond must play an essential role..
- (b) It is best to start by listing the facts about $ATP \rightarrow ADP + P_i + 2H^+$ reaction for which the Wikipedia article (see <https://cutt.ly/xFbuDet>) gives both graphical representation and the overall formula for the reaction.

In the initial state 4 O-atoms of ATP have a visible negative charge. The simplest assumption is that all ions O^- actually correspond to gravitationally hydrogen bonded $O \dots H$ pairs with a delocalized proton charge so one should use the notation $O^{\prime -}$. O^- would be replaced with $O \dots H - O - H$ such that the HB carries a gravitationally dark proton delocalized in even astrophysical scale. The negative charge would be only effective and associated with $OH^{\prime -}$ rather than being a real negative charge of O^- . The same assumption is natural also for ADP and AMP. This would define the meaning of organic phosphates. In the final state both P_i and ADP have visible charge -3 to give a total visible charge -6.

$2H^+$ in the final state guarantees the conservation of the visible charge in the reaction.

- (c) The $P(O^{''-})_2$ of the third phosphate transforms to an inorganic phosphate P_i . A natural interpretation is that the gravitationally dark protons become ordinary ones. This explains $2H^+$ in the final state. This reaction would liberate part of the metabolic energy.
- (d) One H_2O molecule is used in the reaction. The natural assumption is that one hydrogen of H_2O has a dark gravitational HB with the oxygen appearing in $O-P$ of $(O_2^{''-}P=O)-O-P...$ so that it has $O^{''-}$ visible charge -1. The bond $...P-O-...H$ becomes the effective oxygen ion of $...P-O^{''-}$ of P_i so that P_i would not be completely inorganic. The remaining OH of the water molecule becomes one $O^{''-}$ of P of ADP. Also this reaction can liberate metabolic energy.

14.2.6 Gravitational magnetic body and the model of dark DNA

Dark DNA (DDNA) is identified in terms of dark proton triplets assigned with flux tubes parallel to DNA. Codons correspond in the original model to smaller circular flux tubes carrying the dark proton triplets. This model is modified by replacing the circular flux tubes with long U-shaped gravitational HBs. In order to avoid confusion, one must make clear that this realization of DDNA differs from that discussed in [L141] and one must check whether they are consistent and what new predictions follow from the recent, much more specific, model.

Original model of DDNA

The original proposal for DDNA was that the dark proton charge screens the negative charge of phosphates so that the charge associated with the DDNA codon would be +3. If one has dark nucleons (proton and neutron), also other charges than +3 are possible in the proposed model and would be needed for amino acid polymers (AAs) [L141].

The most recent model discussed in [L141] made the following assumptions.

- (a) Dark nucleotides correspond to closed loops containing a dark nucleon: both dark protons and possibly effectively dark neutrons are possible so that dark nucleon has spin and strong isospin corresponding to 4 letters of the genetic code. A dark neutron could be only effectively a neutron and could be formed from a dark proton, which has transferred its charge to a flux tube connecting it with the neighboring dark proton.

The total charge is that for dark protons as required by the condition dark DNA charge is neutralized. This conforms with the model for the formation of dark protons by Pollack effect [I126, L25, ?, ?] as transfer of ordinary protons to dark protons at flux tubes possibly forming dark codons as dark proton triplets [L25].

The flux tube could be regarded as analogous to dark π^0/π^- or dark Z^0/W^- . These two options could be dual descriptions as the conserved vector current and partially axial current hypothesis of old fashioned hadron physics suggest.

- (b) The loop carries angular momentum and the angular momenta of dark protons and dark nuclei sum up. The tensor product decomposition of the states obtained in this manner gives DDNA, DRNA, DtRNA, and DAA therefore unifying the counterparts of the basic biomolecules at the dark level.
- (c) A natural expectation is that $\hbar_{eff} = n\hbar$ forms the unit of angular momentum, in particular spin. This gives a very strong condition and strongly suggests that dark particle corresponds to n-particle as analog of Bose-Einstein condensate: dark 3N-protons and dark 3N-photons as representations of genes with N-codons have been indeed suggested to play a key role in TGD inspired quantum biology. Dark photons with energy of $E = \hbar_{eff}f$ would correspond to $n_{eff} = \hbar_{eff}/h$ dark photons forming an analog of BE-condensate.

Dark space-time sheets X^4 correspond to n -sheeted structures with Galois group of n -D extension of rationals. Many-sheetedness could correspond to many-valuedness of X^4 as a map $M^4 \rightarrow CP_2$ or vice versa and one can have also have n_1 - and n_2 valuedness with $n = n_1 n_2$. In fact, one has a natural factorization of the order of the Galois group to a product of integers corresponding to its decomposition to normal subgroups so that $n = n_1 n_2 \dots n_k$ is the general proposal. n_{gr} (assigned to h_{gr}), n_{em} , n_{weak} , n_{color} can have further decompositions. n -sheetedness with respect to CP_2 would correspond to n copies of a space-time sheet in M^4 , for instance parallel flux tubes forming a quantum coherent structure. For h_{gr} this would be the natural option and for $n_{gr} = h_{gr}/\hbar = n_{gr} \sim 10^{14}$. In this case, N-codon interpretation is not appropriate not natural, rather n_{gr} gravitationally dark DNA flux tubes could integrate to a quantum coherent parallel structure with a size about 1 mm.

The revised model of DDNA

In the model of DDNA-DNA considered here gravitationally dark HBs would define the dark codons.

- (a) The earlier model is modified by replacing the closed flux tubes associated with the dark nucleons with gravitationally dark HBs.
- (b) There is no screening now, and the negative charge of phosphates is only effective and assignable to water molecules surrounding DNA rather than phosphates directly so that DNA stability would be achieved also now.
- (c) Dark DNA has still effective charge -1 per codon and the dark proton charge would be delocalized at the dark gravitational flux tubes and thus invisible. DDNAs would be connected by quantum numbers of loopy flux tube pairs with quantum numbers π^0 or π^- connecting dark nucleons of dark DNA. A dark proton at the strong flux tubes would transform to an effective dark neutron in the case of π^- . The value of h_{eff} for these would most naturally correspond to h_{color} .

I have proposed that even the nucleons of ordinary nuclei can have dark flux tubes, which emanate from nuclei of nuclei and carry quantum numbers of pions and having size of even atomic scale. This could relate to the observed discrepancy of the radius of protons. As a matter of fact, this would mean the counterpart of dark HBs at the level of strong interactions.

- (d) What is new as compared to the earlier model is that there would be a composite of n_{gr} more or less parallel DNA flux tubes assignable to a volume of order 1 mm and each having a length proportional to h_{gr} . Also single flux tube visiting through all the DNAs can be considered. One would have a flux tube spaghetti also assumed to be generated in the formation of astrophysical objects [L83, L88, L117].

Could the HBs associated with the base pairs of DNA become gravitationally dark?

DNA base pairs are connected by 2 (A-T) or 3 (G-C) HBs: what could this mean from the point of view of DNA energy metabolism?

- (a) If these strands can appear as dark gravitational strands, the maximum of 2 (3) metabolic quanta could be liberated in A-T (G-C) pairs via a transformation to ordinary HBs. Could this serve as a yet-unidentified source of metabolic energy in the replication and transcription?
- (b) Could the dark/organic mono-phosphates of the double DNA strand serve as a source of metabolic energy for DNA transferred to the HBs connecting base pairs?

- (c) Suppose that the DDNA parallel to DNA corresponds to a sequence of gravitational HBs B_{gr} as loops associated with the organic phosphates. Codon would correspond to a bound state of dark protons associated with three dark gravitational HBs.

Consider an ordinary HB A_o associated with a base pair and B_{gr} associated with the corresponding dark/organic phosphate. Can one transform A_o to A_{gr} to achieve the transfer of metabolic energy?

Two reconnections for a HB pair (A_o, B_{gr}) can transform the pair to (A_{gr}, B_o) . The gravitationally dark proton and metabolic energy would be transferred to basepair from the organic phosphate, which itself would become an organic phosphate ion P_1^- .

Note: Also the phospholipids of the cell membrane are accompanied by a monophosphate group. Also microtubules are accompanied by GMPs. Could they serve as metabolic energy sources in the cell membrane using the above described mechanism?

A quantum gravitational mechanism for the splitting of HBs associated with base pairs

The splitting of HBs associated with base pairs [?] (<https://cutt.ly/9FmJywe>) plays a fundamental role in DNA opening necessary for DNA replication and transcription. These HBs must split during replication and transcription and many other processes such as selective recognition of DNA by proteins, regulation of RNA cleavage by site-specific mutations, and intermolecular interaction of proteins with their target DNA or RNA. Could the notion of gravitational HB provide insights about the process?

- (a) As the figures of (<https://cutt.ly/PFmJaFr>) illustrate, the base pairs of the double DNA/RNA strand have 2 or 3 HBs. HBs of type $N - H...O$ and $H - N...O$ and $N - H...N$ (called imino HB) are possible. Imino HB appears for both A-T with 2 HBs and G-C with 3 HBs.

Since the hydrogen of $X - H...Y$ is nearer to Y than X , the splitting is expected to give $X + H - Y$, $X, Y \in \{N, O\}$. This is indeed the case when X and Y are different. However, the imino HB $N - H...N$ actually splits to $N - H + N$ rather than the expected $N + H - N$. An exchange of a hydrogen atom is said to occur.

- (b) The temporary formation of a gravitationally dark HB could explain how this is possible. The gravitationally dark proton is at a large distance from the N atoms so that they are in a symmetric position and both outcomes for the splitting are equally probable so that the exchange rate increases.
- (c) This requires a temporary transformation of $N - H...N$ HB to a gravitationally dark HB. Could double reconnection transform the pair (A_o, B_{gr}) formed by $N - H...N$ HB and dark HB of phosphate bond to (A_{gr}, B_o) , which then splits?

Quantum gravitational explanation for the different chemistries in vivo and in vitro

If gravitationally dark hydrogen and VBs are relevant to biology, their effects should distinguish between matter in vivo, gel phase and matter in vitro. The difference should be especially clear at physiological temperatures. Is there any empirical evidence for the deviations from what is inspected on the basis of the standard biochemical intuition?

The interactions between DNA metal ions present living matter could serve as a test for the proposal. In the TGD framework, both metal ions and DNA could be gravitationally dark (in vivo or gel phase) or ordinary (in vitro phase).

- (a) For the DNA and metal ions as they are usually understood, the phosphate ions $(PO_4)^-$ of DNA should have interactions with metal ions and the concentrations should affect the properties of DNA. This should be true both in vivo and in vitro.

- (b) In the TGD framework, DNA strand in vivo and in gel phase would be accompanied by a dark DNA strand. The phosphate ions $(PO_4)^-$ would be actually pseudo-ion $(PO_4)^{*-}$, in the sense that the ion O^- would be replaced with a gravitationally hydrogen bonded structure $O...H - O - H$ such that the HB carries a gravitationally dark proton delocalized in a very long scale. The effective negative charge would be associated with OH^{*-} pseudo ion rather than being a real negative charge assignable to O .

Outside the physiological temperature range and in vitro, the oxygen ion would be real and the situation would be as in the standard chemistry apart from the possible effects of darkness of metal ions. The simplest assumption is that both metal ions and DNA are dark at the same temperature range only.

- (c) (Gravitationally) dark metal ions of type X^{++} would also have a dark valence electron at flux tube. One can speak of dark salt since flux tube bonds would connect X with H_2O_2 . Same applies to Cooper pairs of dark ions X^+ .

The phosphate of DDNA-DNA pair has Coulomb interaction with neither ordinary nor dark ions but the metal ion would interact with OH^{*-} . This suggests that the presence of metal ions does, and ions in general, has no strong effect on the DNA properties in vivo. Besides realizing genetic code, dark DNA would shield the system from the perturbations caused by various ions.

- (d) Experimentally this seems to be the case. Most interactions between DNA and ions are modelled and studied experimentally in dilute water solutions. According to [I92] (<https://cutt.ly/bFQ1G1a>), under these conditions the DNA interaction with charged ligands, the helix-coil transition temperature, and other DNA properties are strongly dependent on the low-molecular-weight salt concentration, see [I92] and references therein. However, for condensed DNA states (fibers, gels) or in vivo, similar characteristics are often independent of or only slightly dependent on the ionic composition of the solvent.

What about amino-acids (AAs)? The proposal is that also DAA-AA pairing realizes dark genetic code. If this code is realized in terms of gravitationally dark HBs, one expects that the same should be true for AAs.

Dark proteins and quantum gravitation

What about dark proteins in the recent situation?

- (a) In the case of AA of a protein, the effective charge is assignable to the donor atom, which could be either atom of peptide backbone or of water molecule. Can one assign to a given amino acid (AA) of protein (<https://cutt.ly/sFRY1WA>) 3 gravitational HBs carrying a dark proton each?
- (b) In the formation of AA sequence, peptide bonding occurs, which means that $(C = O) - (OH)$ is replaced with $C=O$ and NH_2 is replaced with $N - H$. $(N - H) - (C - H) - (C = O)$ is the unit of peptide backbone (<https://cutt.ly/nFRYnu4>).

The H atom of $N - H$ could form a gravitationally dark HB to O atom of water molecule, which would give N^{*-} . Also N could form HB with H of water molecule: this would give OH^{*-} . $C = O$ could form a dark HB with the H of the water molecule so that OH^{*-} is generated but $=O$ remains neutral. As in the case of DDNA-DNA pair, an effective negative charge of -3 units would be generated if one counts also the COH^{*-} as part of the peptide backbone.

14.2.7 Living systems as analogs of topological quantum computers

Topological quantum computation (TQC) has in the TGD framework a realization in terms of braids realized as magnetic flux tubes connecting subsystems [K4, K3, K135]. The flux tubes carry $h_{eff} = nh_0$ phases of ordinary matter behaving in many respects like dark matter. In living matter TQC-like activities would be realized in several scales associated with the hierarchy defined by the levels of MB and one can even speculate that TGD is the basic function of living matter. This motivates a brief comparison of TGD based view about quantum computation (QC) and TQC with the standard view.

Basic distinctions from the standard view

The TGD based view about quantum computation (QC) [K4, K3, K135] differs in several aspects from the standard view.

- (a) The hierarchy of Planck constants makes it possible scale the time and spatial scales of QC by realizing it using dark matter as $h_{eff} = nh_0$ as phases for ordinary matter. This is possible at quantum criticality in which long range correlations associated with quantum fluctuations are realized as $h_{eff} = nh_0$ phases, which play a crucial role in the living matter. What is favorable for QC is that for large values of h_{eff} dissipation rate is small.
- (b) The fragility of quantum entanglement is a basic problem of standard QCD. Partially it is due to the smallness of Planck constant. Number theoretic vision predicts that one can assign to quantum entanglement ordinary entanglement entropy and also p-adic entanglement entropy which is possible if entanglement probabilities belong to the extension of rationals assigned to the space-time region considered. $h_{eff}/h_0 = n$ corresponds to the dimension of extension associated with the space-time surface and is determined by the degree of the polynomial determining it at the level of M^{98} ($M^8 - H$ duality). Negentropy Maximization Principle (NMP) is the basic principle of TGD inspired theory of consciousness as a generalization of quantum measurement theory based on zero energy ontology (ZEO).

The prediction is that the quantum entanglement associated with entanglement with positive p-adic entanglement negentropies is very stable and the negentropy of the entire system tends to increase. This implies evolution as an increase of algebraic complexity accompanied by the increase of h_{eff} and quantum coherence scales.

- (c) Negentropic quantum entanglement favored by NMP satisfies strong constraints. In particular, the entanglement probabilities are rational numbers. Therefore this kind of entanglement is very rare. This solves a second basic problem of QC: there are quite too many possible quantum entanglements so that combinatorial explosion is unavoidable.
- (d) ZEO [L89, L112] [K146] allows also QCs in both time directions. In "big" state function reduction (BSFR) the computation halts and the arrow of time is changed and QC in the opposite time direction begins. At the human level the wake-sleep cycle corresponds to the periods separated by BSFRs. The saying that problems are solved, by sleeping over night, makes sense at a deeper level. During this period dissipation looks like self-organization and regeneration of structures, healing, and biological systems would apply this mechanism in all scales in order to fight against second law. One can also ask whether QC forth-and-back in time could make QC much faster.

TQC in the TGD framework

TQC is a very natural option in the TGD framework [K4, K3, K135]. The basic notions are magnetic body (MB) having magnetic flux tubes and flux sheets as body parts and dark matter residing at MB.

- (a) ZEO replaces 3-D quantum states with superpositions of deterministic time evolutions as preferred extremals (PEs) of the basic action principle, and are analogous to Bohr orbits and realize almost ideal holography - required by the realization of general coordinate invariance, in the sense that 3-D data fix the entire 4-surface. PEs are analogous to biological functions, behavior patterns in neuroscience, and computer programs in computer science. SFRs as acts of free will replaced these programs with new ones.

PEs would be 4-D minimal surfaces with singularities of lower dimension. PE is analogous to soap film spanned by frames defining the singularities. As in the case of soap films, the frames give rise to a finite failure of strict determinism and ideal holography. This failure would be a classical space-time correlate for quantum non-determinism, or at least what I have called cognitive non-determinism as a correlate for imagination.

In purely classical physics holography is not realized. It is easy to understand this by thinking in terms of a point-like particle (for which 3-surface is a generalization). A particle at a given point can go in any direction with any velocity. By ideal holography only single direction and unique velocity is allowed.

- (b) Magnetic flux tubes connecting 3-surfaces give rise to networks. 3-surfaces appear as nodes of this network. An interesting possibility is that these 3-surfaces have as a good approximation 2-D projection to 3-space and therefore define membrane-like objects. All membrane like objects, such as cell membrane could be associated with this kind of 4-surfaces.

The flux tube connections are a new element not present in the standard physics. The flux tubes can be idealized as string-like entities. In 3-D space the flux tubes can get knotted and linked with each other and define in this way braids - or rather, generalizations of braids. They would define the topological space-time correlate for a TQC program,

- (c) Fermionic degrees of freedom (quarks at fundamental level giving rise to all elementary particles including bosons and also leptons as the bound states) define the fermionic part of TQC. Fermionic states reside at the ends of braids at the nodes of the network and more generally at the 3-surfaces from which the flux tubes begin.

An important delicacy, forced by the fact that flux tubes carry monopole flux, is that flux tubes associated with a 3-surface are tentacle-like U-shaped flux loops, and their reconnection builds flux tube pairs connecting 3-surfaces.

- (d) Reconnection for U-shaped flux tubes for a pair A,B of nodes forms a flux tube pair connecting A and B. The reversal of this process destroys the flux tube connection. If all flux tube connections from subsystem A to the environment disappear, A de-entangles. Thus it seems that the presence of flux tube pairs makes possible entanglement. The change of entanglement in turn has braiding as a space-time correlate.

The halting of TQC assignable to subsystems could correspond to the de-reconnection process for a subsystem. Partial de-reconnection is also possible and the notion of partial halting might make sense.

The braids are effectively 1-D and their time evolution defines effectively 2-D surfaces inside a 4-D space-time surface. They can form 2-knots as a generalization of ordinary knots which are 1-knots. The reconnection processes define the topology of these 2-knots. For higher-D space-time surface 2-knotting is not possible so that from the point of view of TQC, the dimension $D=4$ for the space-time is completely unique as also the dimension $D=3$ for 3-space.

- (e) Dance metaphor [K4, K3, K135] is a highly useful way to see TQC in the TGD framework. One can think that the nodes of the network are like dances connected to each other by thin threads. Dancers change their partners and define a complex pattern on the dance floor. At the space-time level this defines braiding of the time-lines of the dancers. One can speak of a time-like braid.

Also the threads connecting the dancers are braided and form space-like braid determined completely by the time-like braiding once the initial state of the space-like braid is fixed. This is not quite the case if reconnections splitting or creating threads between dancers take place. One can say that the space-like braiding records the history of the dance hall as analog of akashic records. One can also speak of topological memory.

- (f) The evolution of the entire TGD Universe can be regarded as a fractal hierarchy of TQCs based on the fractal hierarchy of magnetic flux tubes characterized by algebraic extensions of rationals to which one can assign p-adic primes as maximal ramified primes. These in turn define p-adic length scales assignable to the flux tubes. The braiding of flux tubes takes place in all scales. For instance, while moving around, we contribute to a generation of this kind of braids defining analogs of TQCs.

Biochemistry could represent especially refined analog of TQC. The basic notions of biochemistry interpreted in TGD framework correspond to those of TQC according to TGD as described above but also some new elements emerge.

- (a) Consider the TGD inspired view about bio-catalysis [L173]. Reconnection is the basic mechanism of bio-catalysis. According to the TGD based view about bio-catalysis, reactants find each other by using as tentacles U-shaped flux tubes and resonance mechanism.

Flux tubes can touch but this is not enough. There must be a resonance. This occurs if the cyclotron frequencies associated with the flux tubes are identical. This is possible if the flux tubes have the same radius and therefore identical magnetic field strengths and cyclotron frequencies.

If the value of h_{eff} associated with the flux tubes is reduced, the pair is shortened and forces the reactants near each other. The reduction of h_{eff} liberates energy, which in turn makes it possible to overcome the potential wall, which otherwise prevents the reaction from occurring. After the reaction the energy needed to overcome the wall is liberated and can bring U-shaped flux tubes to its original size. Note that the values of h_{eff} tend to be reduced and metabolic energy feed is to provide the energy needed to preserve the distribution of h_{eff} values.

Since reconnection takes place and reaction can produce new nodes, biochemical reactions do not reduce to the notion of gate in the generalized view of TQC.

- (b) Besides reconnection, the notion of tuning is also fundamental and brings a new element to TQC according to TGD. The change of the thickness of the flux tube as the basic motor action of the flux tube (besides reconnection and contraction) changes the cyclotron frequency. The frequency modulation makes it possible for flux tubes to search whether some objects are present in the environment. This would be the basic operation of the immune system at quantum level [K58] [L139]. The tuning of the flux tubes of MBs of the water clusters makes it possible for them to mimic the cyclotron spectrum of invader molecules and this ability explains water memory.
- (c) Bioharmony [L22] [L96, L108, L141] is a further TGD based notion. The proposal is that genetic code has two quantum realizations. The first one is based on dark nucleon sequences with a dark codon realized as a nucleon triplet. For the second realization codon corresponds to dark photon triplet. These triplets behave like quantum coherent units and are analogous to quarks as 3-quark bound states.

The binding mechanism is purely number theoretic and universal. Also genes can be regarded as dark 3N-nucleons or 3N-photons. The states of dark proton triplets correspond to all basic biomolecules DNA-, RNA-, and tRNA-codons, as well as amino acids (AAs).

Bioharmony defines the dark photon realization of genetic code. Communications occur by using 3-chords (or possibly even 3N-chords). The ordinary resonance between participants with the same value of h_{eff} is replaced with 3N-resonance. The allowed

64 3-chords define bio-harmony as a collection of allowed 3-chords. Music expresses and creates emotions and the natural interpretation is that bioharmony is assigned to variants of genetic code which correspond to different molecular moods. Also the energy resonant communications between dark and ordinary variants of codons must be possible and this poses extremely stringent conditions on the basic bio-molecules.

Bioharmony realizes genetic code and would become the basic code of TQC. Codons or even their sequences would serve as addresses. The signal is a sequence of these 3-chords, analog for a piece of music, and is received by resonance mechanism only by receivers which correspond to a sequence of dark nucleon triplets defining the same codons. Note that also partial resonance is possible in which case the number of possible receivers is higher. The principle is the same as in LISP. The message can be coded to the modulation of the frequency scale of chords. The cyclotron resonance peaks define a sequence of pulses making it possible to interpret the message. Nerve pulse pattern could be induced by this kind of pulse sequence.

14.3 Update of the TGD based view of nervous system

The existing TGD based view of the nervous system will be summarized first. After that the basic notions and the ideas about what happens in nerve pulse conduction are sharpened by using the quantum gravitational view about metabolism. Also the relationship between biochemistry and TGD view about quantum biology will be discussed and lead to highly non-trivial insights about the role of the basic biomolecules.

14.3.1 The recent TGD based view of nervous system

The proposal [K96, K44, K98, L100] is that the cell membrane possesses a pre-NS based on cell membranes acting as generalized Josephson junctions.

- (a) The oscillations of membrane potential induce Josephson oscillations as soliton sequences, which represent the ground state of the axon, and possibly also of cilium. A sequence of rotating mathematical penduli in different phases giving rise to a wave is a good analogy. Pre-nerve pulse would correspond to a perturbation of the soliton sequence in which some penduli oscillate instead of rotating, which propagates with the same velocity as the soliton sequence.

One can also consider an alternative scenario in which the roles of rotation and oscillation are changed. The soliton sequence requires more metabolic energy than its oscillatory counterpart and one might argue that the latter is more favored for this reason.

- (b) Generalized Josephson radiation gives rise to sensory communications from the cell membrane to its MB using frequency modulated generalized Josephson radiation with generalized Josephson frequencies $f_J = E_c/h_{eff}$ (and their multiples), which correspond to the energies $E_J = \Delta E_c + ZeV$, where ΔE_c is the difference of cyclotron energies for flux tubes at different side of membrane, and ZeV is the usual Josephson energy. Z denotes the charge of a Cooper pair or bosonic ion. For $h_{eff} = h_{gr}$ the generalized frequencies are in EEG range and nerve pulses appear as frequency modulations of the generalized Josephson frequencies.
- (c) The frequency modulated generalized Josephson radiation is received at MB and induces pulse by cyclotron resonance defining the response of MB as a dark cyclotron radiation. The response of MB corresponds to a sequence of resonance peaks, which induce pre-nerve pulses as propagating perturbations of the soliton sequence. The perturbation would change the rotating motion of the effective gravitational pendulum to an oscillating motion.

The pre-nerve pulse induces a nerve pulse if a quantum criticality condition stating that the magnitude of the resting potential is above the critical value is satisfied. Synaptic transmission builds a contact between pre- and postsynaptic cells and connects U-shaped flux tubes parallel to the dendrites and axon to a pair of flux tubes.

Which part of the neuron could receive the response of MB?

- (a) The original proposal [K96] was that the response of MB occurs directly at the level of the genome. This would require a network of flux tubes connecting cell nucleus and cell membrane transmitting the response from genome to cell membrane. This flux tube network would also make topological quantum computation-like processes possible [K3, K135].
- (b) One can also imagine a simpler scenario. The response would be received by the cell membrane and generate second messenger molecules, which carry a chemical signal to the cell nucleus. The response could be seen as a sensory communication with a reversed arrow of time. The objection is that sensory and motor systems are different for vertebrates. One can however argue that the time reversal is for the combined system. If sensory and motor sub-systems have opposite arrows of time, only either of them contributes to "our" conscious experience at once.

Interestingly, in human EEG there is a clear division into quasi-stationary periods with a duration of about .3 seconds [L18] discussed from the TGD point of view in [L19]. The first half of the period looks ordered and the second half chaotic. I have proposed that these pieces are separated by BSFR at MB as a response of MB and correspond to different arrows of time.

Synaptic transmission is second key part of neural activity.

- (a) Synaptic transmission involves the transmission of a bag of neural transmitters implying that the pre- and post-synaptic cell membranes touch and fuse to a singly entity temporarily. This would imply also the fusion of the magnetic flux tubes assignable to pre- and postsynaptic axons to a single flux tube and make possible both the transfer of quantum coherence and the propagation of dark photon signals assignable to magnetic flux tubes acting as wave guides. The flux tubes could be called pre-axons.
- (b) The deeper function of neurotransmitters remains a mystery in the framework of the standard neuroscience but terms like reward and punishment are routinely used. In the TGD framework, these terms could be more than convenient metaphors.

The neurotransmitters arriving in the synaptic contact could induce a change of the local bioharmony and thus a change of the local mood so that the heuristic terminology would be justified. At the level of the basic biomolecules the epigenetic regulation based on methylation could induce similar changes [L141]. The decision making of neurons would rely on emotions created by various synaptic inputs: this is the situation also at our level!

Axonal MTs could make the conduction of nerve pulses through the myelinated portions of the axon possible. Inside myelinated portions the transfer of ions between interior and exterior of the axonal membrane is not possible. The shortening of axonal MTs involves localization of delocalized protons and electrons at gravitational flux tubes and changes the charge of the axonal interior and this in turn can take the membrane potential below the critical value and make the conduction possible. Note however that the drop of electrons and protons would take place at Bohr orbit with Earth radius. A further localization to atomic level would liberate more energy.

14.3.2 Clarification of some basic concepts

In the following I try to further clarify the basic notions used in order to identify the weaknesses of the scenario.

About the notion of dark ion

The original view was that dark ion as a whole resides at the flux tube. Later this statement became more precise: dark ion touches the, say gravitational, dark flux tube with $h_{eff} > h$. This applies also to both gravitational, electromagnetic, weak, and color flux tubes and ordinary bonds correspond to electromagnetic flux tubes with $h_{eff} = h_{em}$ [L51].

The entire dark ion touching the flux tube would have wave function in the magnetic field of flux tube having the touching point as argument. Cyclotron states are natural.

The more precise view considered already earlier is that one has effective ion: the dark electron or Cooper pair resides at gravitational flux tube is not bound to the atom as effective ion. The predictions for dark cyclotron states are same as for the older picture and the predictions related to the dark electron or proton are new.

About the notion of electric flux quantum

What does one mean the flux tube parallel to axon?

- (a) I have talked assigned to axon a magnetic flux tube parallel to it and accompanied by magnetic flux tubes transversal to it. This would correspond to a 3-D network of flux tubes.

The problem has been how to describe the membrane structure with electric field and electric flux orthogonal to the flux tube. This situation requires genuine electric flux quanta analogous to magnetic flux quanta and the time dependent deformations of the magnetic flux tube cannot give them. However, magnetic flux tubes allow very simple time dependent deformations allowing longitudinal electric flux along the tube.

- (b) Could electric flux quanta associated with a pair of lipid layers correspond to a pair of membrane-like objects having 1+2-D rather than 4-D M^4 projection connected by time-dependent deformations of transversal magnetic flux tubes carrying a longitudinal electric field?
- (c) Unfortunately, I did not have any candidate for an explicit solution of field equations describing 2-D membrane-like object such as cell body or axon. For some time ago I finally understood 2-D membrane-like objects in terms of 3+1-D minimal surfaces in $H = M^4 \times CP_2$.

M^4 projection is 3-D and E^3 projection 2-D membrane. The basic problem is posed by the fact that 2-D closed minimal surfaces are not possible. For soap bubbles a pressure difference over the soap bubble is required and one loses minimal surface property. The solution of the problem was that the 1-D CP_2 projection of the surface is dynamical and allows 4-D minimal surface. The simplest option is that it represents rotating geodesic circle.

- (d) Therefore one can ask whether lipid bilayer could have pair of electric bodies (EBs) serving for them as a kind of template and connected by transversal electric flux tubes carrying a longitudinal rather than transversal electric field.

14.3.3 Gravitationally dark effective ions

Besides organic molecules but also metal ions are fundamental for metabolism and biocatalysis. This led to the TGD inspired proposal that they give rise to dark ions and the recent work gives further support for the view is that gravitationally dark electrons given them their special role

- (a) Various bosonic effective metal ions and their Cooper pairs can get paired by gravitational flux tube with atoms of opposite total valence. The distance between paired

system can become due the relative motion of the atoms considered. Also reconnections of gravitational flux tubes could cause this.

Correlations are predicted between the members of pairs. The presence of gravitational hydrogen- and valence bonds (VBs) implying the presence of effective ions could distinguish biochemistry from chemistry. Also electrolysis, and therefore organic chemistry in general, involves the ionization of atoms very difficult to understand without the notion of dark gravitational valence- and hydrogen bonds. Also the physics of water is full of thermodynamical anomalies suggesting the presence of these bonds.

- (b) According to standard chemistry, one has equilibrium $X(OH)_2 \leftrightarrow X^{++} + 2OH^-$ for $X \in \{Ca, Mg, Fe\}$ in water environment. Gravitational effective ionization effectively breaks charge conservation and one would obtain quantum correlated pairs formed from X^{++} connected by flux tubes H_2O_2 . Gravitationally dark electrons would not be visible. This would mean apparent charge non-conservation, which could be tested as deviation of the concentrations from the prediction $n(X^{++}) = 2n(OH^-)$.

This could happen also for water itself. H_3O^+ and OH^- ions are present. OH is not stable but the pairing $2(H_3O^+) + 2H_2O_2$ by gravitational hydrogen bonds is possible. Also $H_2O + OH^-$ pairs with one dark gravitational proton are possible. The concentrations of $(H_3O)^+$ and OH^- would be different.

Signatures of dark effective ions

The ions X^{++} , $X \in \{Ca, Mg, Fe, Zn\}$ and $X \in \{Li, Na, K\}$ would be actually effective ions with gravitationally dark VBs. Dark effective ions have special signatures, which allow to test the TGD view.

- (a) These effective ions effectively break charge conservation. Is the transformation of $X(OH)_2 \rightarrow X^{++} + H_2O_2$ rather than $X(OH)_2 \rightarrow X^{++} + 2OH^-$ in question as would be if electrons become gravitationally dark. Note that hydrogen peroxide H_2O_2 is a reactive oxygen species (ROS) (<https://cutt.ly/NFima6X>) playing a very important role in biology. ROS are produced in biological processes, in particular metabolic process such as respiration and photosynthesis. TGD view would mean that ROS are not a nuisance but an essential element of electron based metabolism.

For X^+ , $X \in \{Li, Na, K\}$ the electrons of the Cooper pair are paired with two OHs. Two XOHs forms Cooper pair of X^+ :s correlated hydrogen peroxide H_2O_2 . This would represent new physics and effective charge non-conservation.

- (b) Quantum gravitational correlations between H_2O_2 and X^{++} , $X \in \{Ca, Mg, Fe, Zn\}$ and between H_2O_2 and Cooper pairs of X^+ , $X \in \{Li, Na, K\}$ are predicted and this prediction might be testable.

Some facts about Calcium ions

Basic facts about Ca ions allow to get idea about the implications of new metabolic quantum and the quantum gravitational realization of metabolic energy quanta.

- (a) Calcium ions (Ca^{++}) contribute to the physiology and biochemistry of organisms' cells. They play an important role in signal transduction pathways, where they act as a second messenger, in neurotransmitter release from neurons, in contraction of all muscle cell types, and in fertilization.
- (b) Calcium phosphate <https://cutt.ly/4FimgMc> appearing in bones combines effective ions possibly having gravitationally dark protons and electrons (Calcium phosphate is also considered in [L103]). Posner molecule $[(PO_4)^{-3}]_6Ca_9^{+2}$ made of 6 phosphate ions and 9 calcium ions would be the key player and has been proposed to play central role in consciousness theory [L35, J117] (<https://cutt.ly/bFimzjt>). I already mentioned

Posner molecules and a possible realization of genetic code using dark Cooper pairs of electrons. I have considered Posner molecules from the TGD point of view in [?].

- (c) Ca^{++} currents initiate action potentials. Voltage gated Ca^{++} channels emerge first in the maturing of neuron and also in evolution of nervous system (already monocellular eukariotes generate action potentials). Na^+ channels emerge later. The action potentials pulses have a longer dead time for Ca^{++} than for Na^+ .

For instance, Ca^{++} initiates a contraction of muscle and helps to maintain the potential difference over cell membrane, which conforms with the proposed role in electronic metabolism.

- (d) Ca^{++} appears as a second messenger molecule. The TGD view about second messenger molecules is discussed in [L133]. Cell interior, in particular mitochondria and endoplasmic membranes contain storages of Ca^{++} . Mitochondria would thus involve both forms of metabolism.

Ca^{++} waves

Ca^{++} waves could be effective ions due to gravitationally dark Cooper pairs.

- (a) Ca^{++} waves are very important in biology and appear in cell interior and between cells. A calcium wave is defined as a localized increase in cytosolic Ca^{++} that is followed by a succession of similar events in a wave-like fashion. Ca^{++} waves can be restricted to one cell (intracellular) or transmitted to neighboring cells (intercellular).
- (b) Calcium waves are also associated with glial cells. Ca^{++} waves are of special importance in astrocytes and other glial cells [J115]. This should relate to electronic metabolism of the primary cilia associated with both neurons and glial cells.

Calcium waves and miniature potentials would naturally relate to dark electron metabolism. Both glial cells [J90] and neurons [J87] have primary cilia acting as sensory receptors and since cilia cannot use ATP metabolism, electronic metabolism is natural.

14.3.4 About the model for the nerve pulse

Could one construct a simplified TGD based model for the nerve pulse [K96] using this kind of picture utilizing holography meaning that one can take the EBs as basic objects to which one can assign densities of various ions atoms and normal components of electric field as charge densities? Can one decompose these densities to various contribution assignable to ions or effective ions?

The basic physical picture would be as follows. The transformation of the pairs of metal atom with atoms with total valence equal to that of metal would generate gravitationally dark metal atoms, which are effective ions which correlate with the paired atoms. The valence charge of the metal atom effectively disappears and implies an effective charge non-conservation. In nerve pulse these effective ions would disappear and would look like charge non-conservation. Also effective ionic currents appear.

- (a) Josephson currents are assumed to flow along dark flux tubes connecting the two systems and electric field would be along them. Gravitationally dark protons and electrons reside at gravitational flux tubes as very long loops connecting cell interior and exterior. Dark ions are associated with these flux tubes (touch them).
- (b) What kind of dark Josephson currents could flow along them? If the two atoms are localized at the ends of the dark gravitational valence- of hydrogen bond at the opposite sites of the membrane, the dark electron and proton Josephson currents can run along gravitational flux tube. Also effective dark ion currents can flow between interior and exterior since the gravitational VB with H_2O_2 can get stretched.

Gravitational flux tubes assignable to valence and hydrogen would connect systems such as X^{++} , $X \in \text{Ca, Mg, Fe}$ and hydrogen peroxide H_2O_2 , which is a reactive oxygen species (ROS). The currents would flow between systems containing these dark ions and molecules.

- (c) More than 100 miniature potentials induced by Ach vesicles are needed to initiate nerve pulse in synaptic contact. The miniature potential corresponds to a liberation gravitational electronic metabolic quantum as a transformation of gravitationally dark electron to ordinary one. This critical reduction of membrane potential would induce the reduction of the membrane potential below the critical value and induce the action potential. Also protonic metabolic quanta are involved and would relate to the ordinary metabolism based on ATP machinery.

The TGD picture challenges the Hodgkin-Huxley model of nerve pulse generation (<https://cutt.ly/FFiWTNA>). The model for the neuronal membrane assumes that ohmic currents flow through the ion channels. What happens when a Ca^{++} initiated action potential is generated?

- (a) The standard description using Hodgkin-Huxley model is in terms of a rush of Ca^{++} ions to the cell interior along Ca^{++} channels. The process occurs spontaneously since the cell interior is negatively charged and does not require metabolic energy. These currents would be ohmic and dissipative. This description could make sense only in the non-myelinated portions of the axons.

Since only non-dissipative Josephson currents for dark Ca^{++} ions are possible, the rush of dark Ca^{++} dark ions does not seem plausible in the TGD picture. However, the delocalized electronic charge could end up to the hydrogen peroxide H_2O_2 paired with Ca and a genuine Ca^{++} ions would be created. The same applies to Cooper pairs of other dark metallic ions. In the myelinated portions of axon this kind of mechanism could work so that the Hodgkin-Huxley model would describe the situation.

Inside the myelinated portions of the axon, the transformation of gravitationally dark protons to ordinary protons would reduce the associated effective negative charge and make membrane potential more positive and take it below the critical value for nerve pulse generation at non-myelinated portions.

Also pairs of dark Ca^{++} ions and dark H_2O_2 pairs from $\text{Ca}(\text{OH})_2$ can be created, perhaps by a double (effective) ionization creating pairs of dark Ca^{++} ions and dark H_2O_2 pairs from $\text{Ca}(\text{OH})_2$ in an electric field in the cell interior. Also dark gravitational VBs associated with Ca would be created in the cell interior and dark electron Josephson currents would be generated. The charge densities inside and/or outside the neuronal membrane would change and affect the membrane potential. This option could be realized in the non-myelinated sections of the axon in the resting state: nerve pulse would involve a transformation of dark ions to ordinary ones.

- (b) What looks very strange from the TGD point of view is that, although the generation of nerve pulse is spontaneous and is therefore expected to reduce the value h_{gr} , which in turn would liberate energy identified as a metabolic energy, just the opposite occurs. Can one conclude that a BSFR occurs at critical membrane potential and the arrow of time is changed. In this situation the process would be dissipative but in a reversed time direction. Later support for this interpretation will be found.

This raises a question considered from the TGD point of view in [K94]. Do the ion channels and pumps really act as channels for ionic currents or can only electronic, protonic and ionic Josephson currents flow through them?

- (a) The experimental work of Ling, Sachs and Qin [I130, ?] and other pioneers [I95, I70] challenges the notions of ionic channels and pumps central to the standard cell biology. Ling has demonstrated that the ionic concentrations of a metabolically deprived cell are not changed at all: this challenges the notion of cell membrane ionic pumps.

- (b) The work of Sachs and Qin and others based on patch-clamp technique shows that the quantal ionic currents through the cell membrane remain essentially as such when the membrane is replaced by a silicon rubber membrane or by a cell membrane purified from channel proteins! This challenges the notion of cell membrane ionic channels. A further puzzling observation is much more mundane: an ordinary hamburger contains roughly 80 per cent of water and is thus like a wet sponge: why is it so difficult to get the water out of it?

Membrane potential changes sign during the nerve pulse. The interpretation as a BSFR changing the arrow of time is suggestive and the above observation suggests the same?

- (a) If the action potential corresponds to two subsequent BSFRs as a kind of quantum tunneling event, the arrow of time temporarily changes at MB and changes the effective arrow of time at the level of the ordinary biomatter. Gel-sol phase transition in the neuron interior near neuronal membrane signals about the reduction of the quantum coherence scale.
- (b) The TGD based description for the change of the sign of the membrane potential is in terms of the model of nerve pulse describing the ground state as a soliton/oscillon sequence and mathematically equivalent to a sequence of gravitational penduli rotating/oscillating in synchrony. Can one choose between these options?

Critical membrane potential would correspond to a situation in which the rotation changes to oscillation or vice versa. The fact that the membrane potential changes sign and has original magnitude, supports the soliton model. The rotation frequency would transform to a vibration frequency, decrease further, change sign and eventually transform to a negative rotation frequency. The arrow of time would have changed. The reverse of this process would correspond to the second BSFR leading to hyperpolarization.

14.3.5 Microtubular level

TGD predicts two forms of metabolism [L127]. The ordinary metabolism relies on gravitationally dark protons originating from hydrogen bonds. For the new form of metabolism dark protons are replaced with gravitationally dark electrons or their Cooper pairs originating from metal atoms. Both dark electrons and dark electron Cooper reside at gravitational Bohr orbits with the same spectrum of radii. When they transform back to ordinary particles, they become gravitational Bohr orbits at distance defined by Earth radius and therefore liberate energy.

This metabolic mechanism could be associated with cilia and flagella having no mitochondria in their interior and could be also important in the metabolism of axonal MTs.

Could the metabolism of cilia and flagella rely on gravitationally dark electrons?

The recent work in TGD has led to considerable progress in the understanding of metabolism [L127] already discussed in the section 14.2.5. The TGD based view about metabolism involves in an essential way quantum gravity.

The observation is that the gravitational binding energy of dark protons at Bohr orbits in Earth's gravitational field for $h_{eff} = h_{gr} = Gmm/v_0$ [E2] [K36, K37, K38, K39, K88] [L119, L104] can correspond to metabolic energy quantum in good approximation. The proposal is that the transformation of protons of hydrogen bonds possible for electronegative atoms and occurring at least for phosphate generates gravitationally dark protons. Their transformation would liberate metabolic energy quantum.

The prediction is that besides gravitationally dark protons also similar electrons define a metabolic energy currency relating to standard metabolic currency like cent to dollar. It is proposed that the electronic metabolic currency can be applied to the purely understood

metabolism of cilia and flagella (<https://cutt.ly/WDkYZzx>). I attach the proposal below almost as such.

According to [?] (<https://cutt.ly/EDkW2bu>) the recent measurements in sea urchin sperm (length $\sim 50 \mu\text{m}$ long, diameter $0.2 \mu\text{m}$) show that the energy consumed per flagellar beat corresponds to $\simeq 2 \times 10^5$ ATP molecules. There is no GTP inside cilium as in the case of axonal MTs (<https://cutt.ly/5DkYGB2>). It is difficult to understand how ATP machinery could provide the metabolic energy feed.

This motivates the question about whether local ciliary metabolism could rely on the transformation of valence electrons of some biologically important ions to dark electrons at the gravitational MB and vice versa? The reduction of h_{gr} for electrons would provide the metabolic energy related by a factor $m_e/m_p \simeq 2^{-11}$ to the ordinary. According [?], about 4×10^8 gravitationally dark electrons would transform to ordinary ones in a single stroke of cilium.

Electronic metabolic energy quantum would relate like cent to dollar and make possible a more refined metabolism with fine tuning. Electronic metabolism could also be an essential part of ordinary metabolism.

Consider now the idea more quantitatively.

- (a) What could be the electronic analog of ATP machinery. All biologically important ions can be considered as effective ions with some valence electrons at gravitational MB. In particular, the bosonic ions Ca^{++} , Mg^{++} , Fe^{++} and Zn^{++} could have Bose-Einstein condensates of gravitationally dark Cooper pairs at the gravitational MB.

Ca^{++} waves play a key role in cellular biology, Fe^{++} is essential for oxygen based metabolism, and Mg^{++} and Zn^{++} are important in bio-catalysis: for instance, ATP must bind to Mg ions in order to become active.

- (b) What could be the mechanism transforming valence electrons to dark electrons? This should happen for positively charged biologically important ions, in particular for the bosonic ions Ca^{++} , Mg^{++} , Fe^{++} and Zn^{++} . The consumption of metabolic energy would correspond to a de-ionization of dark ion Ca^{++} and this might make it possible to test the proposal. For instance, Ca^{++} could accompany ciliary waves.

Where could the energy for ionization come from?

- (a) This question is also encountered in the chemistry of electrolytes [L51]. It is very difficult to understand how the external electromagnetic potentials, which give rise to extremely weak electric fields in atomic scales, could lead to ionization. The acceleration of electrons in the electric field along dark flux tubes involves very small dissipation and can easily give rise to electron energies making ionization possible.
- (b) MTs have a longitudinal electric field which by the generalization of Maxwell's equations to many-sheeted space-time (in stationary situation potential difference is same for paths along different space-time sheets) gives rise to an electric field along the magnetic flux tubes. These flux tubes need not be gravitational.

By darkness, the dissipation rate is low. Could the acceleration along flux tubes, in particular MT flux tubes, lead to the ionization? Could the electret property of linear biomolecules quite generally serve for the purpose of generating electronic metabolic energy storages in this way?

- (c) Assuming opposite charges $\pm Z_{MT}$ at the ends of dark magnetic flux tube associated with the MT, one obtains a rough estimate. The length of the cilium is $L \leq .5 \times 10^{-4}$ m and its radius is $R \sim 2 \times 10^{-7}$ m. The estimate for the energy gained by a unit charge e as it travels through the ciliary MT is $E \sim Z_{MT}e^2L/R^2 \simeq Z_{MT} \times 2.85$ eV. The valence electron energy for atomic number Z with principal quantum number n (giving the row of the Periodic Table) is $E \simeq (Z/n)^2 \times 13.6$ eV. The ionization condition would be $Z_{MT} \geq (Z^2/n^2) \times 13.6/2.85$. For the double ionization in the case of Ca^{++} with $Z = 20$ and $n = 3$ this would give $Z_{MT} \geq 212$.

TGD based view about axonal and cellular microtubules

Axonal MTs and also subset of MTs in the cell body are highly dynamical critical systems changing their length continually. It seems that they are essential motor instruments of MB just like the MTs of motor cilia. Could the microtubular structures in cell soma are also analogous to supporting structures which can be rapidly deformed by making them unstable against the change of length.

1. *Instability of axonal MTs and nerve pulse conduction*

In the TGD framework, axonal MTs could make nerve pulse conduction in the myelinated portions of axons possible. The localization of dark proton charges in the shortening flux tube would change the charge of the MT interior and in this way affect the local membrane potential and bring it to criticality. Time reversal and BSFR could be associated with the change of the growth of the MT length to decrease or vice versa. The lengthening and shortening processes would be the same but have different arrows of time. The propagation of the wave at which arrow of time for MT changes would correlate with the conduction of nerve pulse.

The dynamic instability of the axonal and some cellular MTs (<https://cutt.ly/ADzx3re>) is not well-understood. Power stroke causing the decay of the MT at its end is the basic notion. Whether chemical action precedes the mechanical one or vice versa is not clear. Therefore an obvious question is whether chemistry and mechanics are enough. The following represent a possible TGD based view about the power stroke.

- (a) Gravitationally dark proton transforms to ordinary proton of a phosphate hydrogen bond in the transformation of GTP to GDP. This liberates metabolic energy quantum, serving as a power stroke. This localizes one unit of proton charge and in this manner affects membrane potential.
- (b) Assume that MT is associated with a cylindrical membrane, that is 4-D minimal surface with 3-D M^4 projection having no counterpart in GRT. M^4 projection would have the microtubular cylinder as an E^3 projection. Cylinder is not a minimal surface and the cylindrical analog of the soap bubble requires a pressure difference over the cylinder walls.

In the TGD framework, CP_2 projection as a dynamical 1-D curve, say rotating geodesic line of CP_2 would give rise to the effective pressure difference [L121]. This analog of pressure difference would increase in the power stroke and locally expand the cylinder at the position of GDP. This would push tubulin protein outwards. These kinds of power strokes would force the MT to decay and shorten.

2. *Energetics of the axonal transport*

The transfer of material along the MT is the basic motor activity of MTs (<https://cutt.ly/TDz0ePw>). The transfer of protein cargoes is a very slow process even on human time scales. Therefore these processes could involve electron (Cooper pair) based metabolism in an essential way. Note however that mitochondria are present also inside MTs.

If electronic metabolism is in question, these processes are predicted to be much slower than those induced by protonic metabolic currency since the work $F\Delta x$ done by the force corresponds to metabolic energy quantum and for Δx about tubulin size, F smaller by a factor m_e/m_p than in the case of protonic metabolic quantum.

Delayed luminescence for microtubules, quantum gravitation, and the mechanism of anesthesia

Jack Tuszyński has reported very interesting findings in Science of Consciousness 2022 (<https://cutt.ly/PF60cxA>). The findings are described in a popular article (<https://cutt.ly/tF60hWz>).

A delayed luminescence in microtubules (MTs) irradiated by laser light has been observed. This can be seen as a support for the presence of quantum coherence at least in the scale of MTs. Also it was found that the application of anesthetics (such as noble gas Xenon expected to have very weak chemical effects) shortens the delay time. This suggests the reduction of quantum coherence by anesthetics so that quantum coherence in long scales should be crucial for consciousness. One of the challenges is to understand the reason for the reduction of quantum coherence.

Delayed luminescence has been associated with bio-photons a long time ago and DNA is proposed to serve as the seat of the delayed luminescence. In particular, the group involving also Tuszynski has studied the emission of mitochondrial biophotons and their effect on electrical activity of the membrane via MTs [J114] (<https://cutt.ly/XF60qLA>). A TGD based view of biophotons as decay products of dark photons is discussed in [K17, K26].

To my opinion, the findings represented by Tuszynski provide support for quantum consciousness but not specifically for Orch-OR, which still remains a rather poorly defined approach since the statement that Planck scale quantum gravity effects are crucial for consciousness has no concrete content.

The TGD based interpretation of findings of Tuszynski would be as follows.

- (a) The laser beam serves as a metabolic energy feed increasing the value of h_{eff} and therefore the scale of quantum coherence. One can say that this metabolic energy feed creates or wakes up an analog of a conscious living organism: now at the level of microtubule MB. As it "dies" in "big" state function reduction (BSFR) involving the reduction of h_{eff} to a smaller value, not necessarily the normal value $h_{eff} = h$, the loaded metabolic energy is liberated.

This would not apply only to MTs but quite generally. For instance, biophoton emission from cut leaves, would represent a similar decay process. Biophotons would be ordinary photons resulting as decay products of dark photon BE condensates and dark photons emitted with cyclotron Bose-Einstein condensates decay.

- (b) The delocalization mechanism associated with the formation of the gravitational variants of hydrogen- and valence bonds allows effective charge densities in short scales and could have dramatic implications for the model of nerve pulse. The nerve pulse need not correspond to a generation of ohmic currents through the membrane but to effective ionization or its reverse process due to the transformation of hydrogen and valence bonds to dark gravitational bonds.
- (c) MTs could play an important role since they involve GTPs as analogs of ATPs and are thus involved with metabolism. The conduction of nerve pulse in the sense of the Hodgkin-Huxley model through myelinated sections of axons is very difficult to understand. The new view would allow the shortening and lengthening of MTs to change the effective charge density of MTs so that membrane potential would change and nerve pulse conduction in the TGD sense would be possible.

How could one understand the effect of anesthetics? I have considered this problem earlier. First one should try to understand how the critical dynamics of MTs relates to nerve pulse conduction inside myelinated regions of the axon.

- (a) Certainly the membrane potential should become hyperpolarized to prevent nerve pulse condition so that consciousness would be lost. In myelinated portions of axons there is only propagating perturbation of membrane potential taking it below the threshold for nerve pulse generation so that nerve pulse is generated at unmyelinated portion. In the ground state one has propagating Sine-Gordon soliton (or oscillon sequence) visualizable as a sequence of rotating (oscillating) gravitational penduli.

In the perturbation some penduli start to rotate in an opposite direction (or oscillation transforms to a rotation). Usually this would require flow of charge through the

cell membrane as Josephson current. Now the variation of the effective charge densities caused by the delocalization of protons inside the axon would induce an effective Josephson current. The effective charge inside the axonal interior becomes less negative and induces at non-myelinated portions of the axon a nerve pulse describable using the Hodgkin-Huxley model.

- (b) A couple of comments about the arrow of time are in order. Nerve pulse is induced by ~ 200 miniature potentials of amplitude about .4 meV which could be assigned to electron metabolic energy quantum. This corresponds to energy of .8 eV, roughly 2 protonic metabolic energy quanta. This supports an interpretation in terms of a time reversed process in which two metabolic energy quanta decay to ~ 200 miniature potentials. This conforms with the proposal that nerve pulse generation is BSFR inducing time reversal.

The reconnection transforming HB (VB) to its gravitational variant or vice versa during nerve pulse propagation induces the transfer of proton (electron) to HB. Since the size scale of the gravitational bond is that of Earth, this would take time and could be too slow for protons. The problem disappears if the reconnection corresponds to BSFR changing the arrow of time. The BSFR occurs and the final state is what becomes the causal agent just as in the explanation of Libet's findings about active aspects of consciousness.

- (c) If the anesthetic induces the transformation of gravitationally dark HBs (VBs) to ordinary ones in the interior of the axon, the effective charge of the axon becomes more (less) negative and the axonal potential becomes more (less) negative. MTs have GTPs near their ends and GDPs in the intermediate region. Negative charges of GTPs and GDPs would naturally correspond to gravitational HBs.

The variation of MT lengths involves a transformation of GTPs to GDPs and vice versa. This would change the effective charge density of the MTs and affect the membrane potential. If gravitational HBs become ordinary, metabolic energy is liberated and vice versa. Hyperpolarization would require a generation of reconnections and a local change of the MT lengths.

The variation of the lengths of axonal MTs would induce effective negative charge near the growing end of MT. Could the moving depolarization front of the axonal membrane correspond to an increasing GDP region of an axonal MT?

- (d) The presence of soliton (oscillon) suggests periodic effective charge density waves in which the protons transform to gravitationally dark protons and vice versa in a periodic manner. Could this mean a periodic variation of the lengths of axonal MTs?

Also the transformation of metallic valence bonds to their dark variants and vice versa could control the membrane potential. Ca^{++} waves would result in cell interior when valence electron pairs of Ca atoms or their salts become gravitationally dark. Could periodic rotation (oscillation) accompany dark electron metabolism with a much smaller energy cost?

How the presence of noble gas having very weak chemical interactions could affect the nerve pulse conduction inside the axon? One can proceed by making questions.

- (a) Could the anesthetic freeze the dynamics of MTs so that nerve pulse conduction would become impossible? The presence of an anesthetic should make the axonal interior more negative and induce hyperpolarization.

Could the presence of the anesthetic stabilize the MTs by minimizing the length of their GDP region? Somehow the growth of MT should be prevented means addition of tubulins and GTPs. This is achieved if the density of tubulin-GTP pairs in axonal water is reduced. The generation of GTP from GDP requires a formation of gravitational HBs from ordinary HBs. The density of ordinary HBs should be reduced.

- (b) Could the presence of the anesthetic reduce the density of ordinary HBs in the axonal water? HBs are associated with water clusters. How could the presence of anesthetic reduce the rate for the generation of water clusters and therefore HBs in the axonal water?

In the TGD inspired theory consciousness, the MBs of water clusters can be seen as correlates for mental images of water as a conscious entity [K58] [L139]. The level of consciousness for water would be reduced. It would be water, which is anesthetized! This would freeze the MTs so that also the axonal membrane freezes electrically.

- (c) Meyer and Overton observed that the potency of anaesthetic agents correlates with their lipid solubility. Anesthetics also seem to affect specific ion channels and receptors. One can argue that if the anesthetic is solvable to lipids, it can also enter inside the axon and somehow reduce the density of HBs assignable to the water molecule clusters accompanied by gravitational MBs. The effective charge of the axonal interior would become more negative and induce a hyperpolarization if the exterior is not affected.
- (d) How happens when water is anesthetized? A hint comes from the Pollack effect [L25]. The exclusion zones discovered by Pollack are negatively charged regions at the interfaces of hydrophilic surfaces. The TGD based interpretation could be that part of protons become dark protons at gravitational HBs. It is known that anesthetics diminish the amount of EZ water (<https://pubmed.ncbi.nlm.nih.gov/27054588/>).
- (e) How could anesthetics prevent the formation of EZs and thus of gravitational HBs? A metabolic energy feed is needed in the Pollack effect and is by photons as also the delayed luminescence for MTs demonstrates. How could the feed of photons needed to produce EZs be prevented by anesthetics? Energy is feeded in resonance. Could the presence of anesthetic change the energy needed to transform HB to dark gravitational HB so that the resonance condition would not be satisfied.

14.4 How multicellular without a nervous system can behave as if it had a nervous system?

In the TGD framework, the quantum models of cell membrane and nerve pulse rely on the notions of magnetic body and dark matter [K44, K96, K98, L100]. The generalization of this view leads to a notion, which could be christened as pre-neural system (PNS). Also the multi-cellulars without CNS would possess PNS.

14.4.1 Animals without the brain behave as if they had the brain

The motivations for this article came from the Quantum Magazine article (<https://cutt.ly/IDnfovQ>) telling about the findings of Manu Prakash and Mathew Storm Bull. The work of Prakash and Bull is published as 3 articles [?] that can be found in arXiv.org. In the following I summarize the findings as they are described in the popular article.

Findings of Prakash et al

Trichoplax adhaerens is a marine creature, classified as a placozoan, which has the smallest known genome in the animal kingdom. *Trichoplax* has thousands to few millions of cells and is between prokaryotes and eukaryotes as far complexity is considered.

Trichoplax (<https://cutt.ly/SD6GGW5>) is a very flat organism formed with diameter about 1 mm and thickness about 25 μm . For cell number N in the range $[10^3, 10^6]$ cells and for a cell approximated as a ball with radius r , this gives r in the range $[2.1, 21] \mu\text{m}$. Despite the lack of neuronal system and muscles, the motion of *trichoplax* is extremely well-orchestrated and efficient.

The goal of the project of Manu Prakash and his graduate student Matthew Storm Bull was to understand how the neuromuscular system might have evolved and how the early multicellular creatures without a nervous system managed to move, find food and reproduce. Epithelial sheets formed by *Trichoplax* cells are studied. *Trichoplax* cells are monociliated that is they have only a single cilium. This simplifies the experimental study and modelling of *Trichoplax*.

First some basic facts.

- (a) Motile cilia and flagella are the analogs of muscles and primary (non-motile) ciliar serve the role of sensory organs at the cellular level. Cilia and flagella have similar structures and only their functions differ. Cilia force liquid to move with respect to the cell. Flagella make it possible for the cell to move with respect to liquid (<https://cutt.ly/TDngqh0>).
- (b) The force needed for the bending of the cilium is produced by the outer and inner dynein arms of the axonemal MT doublets connected to the central pair of microtubules by radial spokes. Airway cilia have components typical for motile cilia.
- (c) Beating waves as contraction waves of the axoneme induce bending of the cilium. The frequency of the beating wave is the key parameter in the dynamics of the cilium.

That the beating frequencies are in the EEG range suggests that in some respects neurons and ordinary cells have much more in common than thought. Beating frequency would take care of synchrony and one can ask whether cilia have an analog of EEG.

Popular summary of the experimental findings

I add to the summary my own comments in order to give a hint about TGD based interpretation of the findings.

- (a) The claim is that behavior of *Trichoplax* can be described entirely using the language of physics and dynamical systems.

Comment: To my understanding, a description in this sense means mathematical modelling using formalism of physics and identifying simple basic mechanical functions serving a role analogous to program modules of the software.

The nature of the living systems is very difficult to understand using only recent day physics and it is very difficult to believe that purely mechanistic description could be possible. However, the possibility to construct such a simple model is in itself a strong guideline in attempts to really understand how the motor actions of *Trichoplax* are possible.

- (b) Cilia are typically seen in the context of fluids: propelling bacteria or other organisms through water, or moving mucus or cerebrospinal fluids in a body. Therefore the expectation was that the cilia to glide over surfaces, with a thin layer of fluid separating animal and substrate. But when the researchers looked through their microscopes, they saw that the cilia seemed to walk, not swim.

The claim is that instead of hydrodynamic description, it is possible to have much simpler description in terms mechanics involving notions like friction and adhesion.

Comment: I understand that these conclusions hold true for the motion along the surface and one can wonder whether the conclusions hold true for swimming.

- (c) The characterization of the cilia's walking gait was taken as a goal. Only three types of basic motions: slipping, during which the cilia barely grazed the surface; walking, when the cilia adhered to the surface briefly before popping off; and stalling, when the cilia got stuck against the surface.

Comment: What is really surprising is that the motion consists of such simple basic modules somewhat like a computer program. For instance, in a general Hamiltonian

system one expects Hamiltonian chaos. Bohr orbits are what comes into the quantum mind.

Mechanical models for the walking activity were developed by the authors [I165, I163, I164].

- (a) In the models the walking activity emerged naturally from the interplay between the internal driving forces of the cilia and the effective energy of their adhesion to the surface. The right balance between those two parameters (calculated from experimental measurements of the cilia's orientation, height from the surface and beat frequency in the EEG ranfe in the situation considered) resulted in regular locomotion, with each cilium sticking and then lifting away, like a leg. The wrong balance produced the slipping or stalled phases.

Comment: My understanding is that the driving force of the cilium serves as an input analogous to external force and chosen so that a model for a particular motion is obtained. The model is therefore not fully deterministic and autonomous. On the other hand, the reduction of hydrodynamical description to mechanical description is highly non-trivial and suggests that some new physics is involved.

- (b) The walking cilium can be modeled as an excitable system. In an excitable system, the signals spread and get amplified rather than progressively damping out and coming to a stop. A neuron is a classic example of an excitable system. Small voltage perturbations can cause it to fire suddenly, and above some threshold, the new stimulated state propagates to the rest of the system.

The same phenomenon seems to occur in the cilia. In the experiments and simulations, small perturbations in the height of cilium from the surface, rather than voltage, led to relatively large changes in the activity of nearby cilia. They could suddenly change their orientation, and even switch from a stalled state to a walking one.

Comment: Excitability, and self-organization in general, is in conflict with the expectations based on second law of thermodynamics. The metabolic energy feed is the way to understand the situation in non-equilibrium thermodynamics.

This behavior requires an highly non-linear mechanical system at criticality. This does not however explain why so few modes, in fact analogous to Bohr orbits, are possible. A quantum biologist could ask whether quantum criticality is involved. At classical level catastrophic theoretic description in terms of phase transitions is suggestive.

The similarities with neuronal behaviors inspire the question whether the ciliary system defines some kind of pre-neuronal system preceding the nervous system in evolution and shared by it as the fact that sensory receptors are cells with cilia.

- (c) It was measured how the mechanical gait of each cilium led to small, local fluctuations in the height h of the tissue. Equations for how this would 'tug' at nearby cells to affect their behavior were deduced, even as the cilia on those cells cycled through movements of their own. A convenient analogy is a network of springs tied together by tiny oscillating motors.

When the researchers modeled this dance between elasticity and activity, as they called it, they found that the mechanical interactions of cilia pushing against a substrate and cells tugging at each other transmitted information rapidly across the organism.

Stimulating one region led to waves of synchronized cilia orientation that moved through the tissue. This elasticity and strain in the physics of a walking cilium, now multiplied by millions of them in a sheet, gives rise to coherent motile behavior.

Comment: Here it is difficult to avoid the question whether the 'tug' as touching of cells (or cilia of different cells) is analogous to synaptic transmission in the neural system.

- (d) The synchronized orientation patterns could be complex. Sometimes the activity of the system produced vortices, with the cilia oriented around a single point. In other cases,

the cilia reoriented in fractions of a second, first pointing one way and then another flocking as a group of starlings or a school of fish might, and resulting in an agility that made it possible for the animal to sometimes change direction on a dime.

Comment: Courageous quantum biologists might associate with the agility a quantum jump in multi-cellular scale.

- (e) It was found that the information transmission was selective. After certain stimuli, the energy injected into the system by the cilia just dissipated instead of spreading and changing the organism's behavior. As if the organism would direct its attention to particular parts of the perceptive field and react only to the changes in these parts.

Comment: Brain is able to direct its attention to particular objects of the perceptive field. Is the ciliary system able to direct its attention?

The model for the cilium and ciliary motor actions

The model starts from the model of nerve pulse and generalizes it to the case of cilium.

Concerning the understanding of the findings about the motor actions of multi-cellulars without a nervous system, this vision raises obvious questions.

- (a) MB should serve as the "boss" also for the multi-cellulars without a nervous system. The general quantal sensory communication and control mechanism should be the same as for organisms with a nervous system. Frequency modulated dark Josephson radiation should mediate sensory data to MB and dark cyclotron radiation would mediate the control commands from MB as pulse patterns as a response to sensory input.
- (b) Could the beating wave, which has frequency in EEG range, be analogous to EEG wave, membrane oscillation, and possibly perturbed oscillon/soliton sequence, which defines the ground state of ciliary membrane?
- (c) Cilia are analogous to axons. Could ciliary membrane act as a Josephson junction communicating sensory data to MB? The MTs of the motile cilia play a role analogous to that of axonal MTs as motor organs of MB. Could one consider analogs of nerve pulses for cilia inducing ciliary motor actions rather than nerve pulse patterns? No nerve pulse is involved. Could the analogs of nerve pulses be pre-nerve pulses analogous to miniature potentials of .4 meV generated in synaptic contacts for instance by acetylcholine containing vesicles (<https://cutt.ly/JD1ONEu>) and induce beating waves inducing ciliary bending? 100-200 hundred miniature potentials are needed to generate a nerve pulse.
- (d) Here the poorly understood origin of the ATP needed by ciliary motor activities [?] serves as a guideline. Cilia and flagella cannot have mitochondria as ATP sources inside them and the diffusion of ATP from nearby mitochondria is strongly limited. The proposal discussed in [?] is that a local generation of ATP using mechanisms, which depend on nutrients could solve the problem. It is difficult to avoid the feeling that something strange is involved with the ciliary metabolism.

TGD leads to the proposal that the standard metabolic energy quantum of about .5 eV corresponds to the change of gravitational binding energy as a proton of HB is transferred to a dark proton at the gravitational flux tube around its Bohr orbit in the gravitational field of Earth with gravitational Planck constant $h_{eff} = h_{gr} = GMm/v_0$. Dark electrons would correspond to gravitational binding energy for a valence electron or a pair of valence electrons (Cooper pair) transferred to a gravitational flux tube.

The energy of the single electron metabolic energy quantum would be by a factor $m_e/m_p \sim 2^{-11}$ smaller than the standard metabolic quantum about .25 meV and relate to the standard metabolic energy quantum like cent to dollar. For an electron Cooper pair it would be 2 times larger and about .5 meV. Intriguingly, this energy is rather near to the Coulomb energy change assignable to the miniature potentials .4

meV (<https://cutt.ly/vDRysfU>)! Could the analog of nerve pulse be a propagating miniature potential induced by the dropping of an electron Cooper pair of say Ca^{++} ion from the gravitational Bohr orbit back to Rydberg state with very small binding energy.

- (e) Cilium is modelled as a 2-D quantum gravitational pendulum with gravitational Planck constant controlled by MB using electronic metabolic energy quanta and the resulting model for the motion is in many respects similar to the model of nerve pulse. In the resting state ciliary penduli oscillate or rotate with constant phase difference so that a wave-like motion results.
- (f) The analog of nerve pulse transmission can be identified. Temporary fusion of pre- and postsynaptic cells takes place in nerve pulse transmission. The tugs would correspond to the adhesion of their cilia and make possible the transfer of quantum coherence and synchrony between the neighboring cells and in this way generate quantum coherence in multi-cell scale? The adhesion of cilium to the plane in which it moves is also possible.

Both kinds of adhesions spoil the synchronous oscillation of neighboring penduli. The adhesion followed by de-adhesion changes the relative phase and a further 'tug' is plausible. This leads a domino effect to an analog of nerve pulse conduction. In this process, the U-shaped flux tubes assignable to the cilia of the neighboring cells fuse to form a larger quantum coherent unit. Same would happen in the case of ordinary nerve pulse transmission [L100]. The system is quantum critical in the sense that when the cilia oscillate/rotate with a phase difference below some critical value, no touchings occur and no nerve pulses are generated. Perturbations change the situation.

14.4.2 Ciliary flocking and emergent instabilities enable collective agility in a non-neuromuscular animal

It is useful to start with a more technical summary of the work of Prakash *et al* provided by the abstract of the article "Ciliary flocking and emergent instabilities enable collective agility in a non-neuromuscular animal" [I165] by Mathew Bull, Vivek Prakash, and Manu Prakash as such.

Effective organismal behavior responds appropriately to changes in the surrounding environment. Attaining this delicate balance of sensitivity and stability is a hallmark of the animal kingdom. By studying the locomotory behavior of a simple animal (Trichoplax adhaerens) without muscles or neurons, here, we demonstrate how monociliated epithelial cells work collectively to give rise to an agile non-neuromuscular organism.

Via direct visualization of large ciliary arrays, we report the discovery of sub-second ciliary reorientations under a rotational torque that is mediated by connective tissue mechanics and the adhesion of cilia to the underlying substrate. In a toy model, we show a mapping of this system onto an "active-elastic resonator". This framework explains how perturbations propagate information in this array as linear speed traveling waves in response to mechanical stimulus.

Next, we explore the implications of parametric driving in this active-elastic resonator and show that such driving can excite mechanical 'spikes'. These 'spikes' in collective mode amplitudes are consistent with a system driven by parametric amplification and a saturating nonlinearity.

We conduct extensive numerical experiments to corroborate these findings within a polarized active-elastic sheet. These results indicate that periodic and stochastic forcing are valuable for increasing the sensitivity of collective ciliary flocking. We support these theoretical predictions via direct experimental observation of linear speed traveling waves which arise from the hybridization of spin and overdamped density waves. We map how these ciliary flocking dynamics result in agile motility via coupling between an amplified resonator and a tuning (Goldstone-like) mode of the system. This sets the stage for how activity and elasticity can self-organize into behavior which benefits the organism as a whole.

14.4.3 The analog of the nervous system at the level of multi-ciliary system

The TGD based model for nerve pulse and EEG generalizes in a rather straightforward manner to cilia.

- (a) Ciliary membranes define pre-neural system. The membranes act as generalized Josephson junctions. The modulations of the oscillation frequency of dark Josephson radiation code for the sensory input to MB. Beating waves have frequencies in EEG range and define the analogs of EEG waves as propagating oscillation patterns of the membrane potential.
- (b) The first guess is that non-motile cilia serve as sensory receptors mediating sensory input to MB as dark Josephson radiation and motile cilia as motor instruments of MB and analogs of muscle. Trichoplax has only a single cilium, which acts as a motor organ. Does it also act as a sensory receptor, or does the remaining cell membrane serve in this role?
- (c) Pre-nerve pulses at the level of animal would correspond to perturbations of the soliton sequences or their oscillatory variants: either one rotating/oscillating pendulum starts to oscillate/rotate. This transition would be induced by the response of MB and cyclotron resonance pulse. Nerve pulse/action potential would be replaced by propagating miniature potential.
- (d) The ciliary counterparts of action potentials would be analogs of miniature potentials and induced by the electronic metabolic energy quantum. They would represent the response of MB at cilia, propagate to the basal body and proceed as chemical communications to the cell nucleus using second messengers and induce gene expression as a response.
- (e) The ciliary MBs of cells organize to a larger MB controlling the motion of cell and the MBs of cells in turn organize to even larger MB controlling the collective motion.
- (f) Synaptic transmission would be replaced with 'tug, that is the touch of neighboring cells, making possible the transfer of the beating waves between the cells. If the touch reduces to the touch of the cilia, the connection with the model of nerve pulse transmission would be even closer. Note however that there is only one flagellum per Trichoplax cell. The orbits of straight ciliar define cones, which correspond to 2-D space-times in 4-D space-time.

The intersection of these surfaces consist of discrete points in the generic case. If the neighboring cilia rotate with the same frequency and are in the same phase so that the minimal distance between ciliar remains constant, they cannot touch. Above some critical phase difference touching can take place and the touching can occur and the neighboring cilia drop from the phase synchrony.

- (g) The quantum coherence extended in the fusion of the ciliary MBs generated in the touching of cells or individual cilia. Does also the transfer of local bioharmony take place in the touch. Are the analogs of transmitters involved and affect the bioharmony of the MB of the receiving cell just like nerve transmitters are proposed to do?

14.4.4 TGD based interpretation of the findings of Prakash *et al*

The findings described in the articles [I165, I163, I164] have made it possible to develop a TGD based picture about the situation.

Homeostasis in the TGD Universe

In biology the balance between sensitivity and stability modelled by Prakash *et al* is known as homeostasis. In biological view, homeostasis is based on a complex many-layered control hierarchies analogous to those used in computation as if a master programmer had written these programs. But can these kinds of control hierarchies really emerge in standard physics?

The proposal of the model of Prakash *et al* is that the 'active-elastic' resonator as a relatively simple mechanical system can at least mimic homeostasis. The model for the epithelial sheet of the animal as a set of oscillators representing cilia coupled by strings. The direction of the cilium defines an effective spin. A resonant coupling of this spin to an external torque represents the control of the motion and parametric resonance allows energy cascades creating collective responses.

In the TGD framework, homeostasis emerges spontaneously via the second law of thermodynamics in reverse time direction.

- (a) In zero energy ontology (ZEO), biological self-organization and homeostasis involve in an essential manner the possibility of time reversal occurring in "big" (ordinary) state function reduction (BSFR) occurring in long length scales. Time reversal changes repellers to attractors so that homeostasis as an ability of the system to stay near the critical point becomes possible by performing BSFRs.
- (b) Dissipation of energy is a process in which the coherence scales of excitation decreases. Time reversed periods mean dissipation with a reversed arrow of time and in the model of Prakash *et al* they would correspond to energy cascades proceeding from short to long length scales.

Parametric amplification and a saturating nonlinearity can be seen as the mathematical model for the BSFR inducing time reversal.

- (a) 'Spikes' mean amplification and in ZEO they could correspond to BSFR changing the arrow of time at the level of MB so that the amplification process would reduce to dissipation with a reversed arrow of time.
- (b) I have proposed that the interpretation of nerve pulse as a pair of BSFRs temporarily changing the sign of resting potential. An analogous interpretation could make sense now.

Cilium as a quantum gravitational pendulum

The findings of Prakash *et al* makes it possible to consider a concrete TGD inspired model for a single cilium and its dynamics.

- (a) The observed sub-second time scale for the ciliary reorientations conforms with the interpretation of beating waves are analogs of EEG waves transformed to mechanical waves as longitudinal contraction waves of cilium causing the bending. These waves would be induced by the membrane potential waves of ciliary membrane and in TGD corresponds to waves associated with the Josephson junction defined by the membrane communicating data to the MB of the system characterized by $h_{eff} = h_{gr} = GMm/v_0$.
- (b) In the first approximation, one can idealize the cilium/flagellum as a rigid linear object of radius $r = .2 \mu\text{m}$, length $l = 100 \mu\text{m}$, and with a density not far from the density of water of 10^3 kg/m^3 . The presence of gravitational Planck constant suggests that one can model cilium as a gravitational pendulum with a mass independent oscillation period $T = 2\pi\sqrt{l/g}$, which corresponds to a sub-second time scale $T \simeq .2 \text{ s}$ for $l = 100 \mu\text{m}$.

The values of l vary in a wide range. For $l = 20 \mu\text{m}$ mentioned as an upper bound for the length of flagellum, one has $T \sim .1$ corresponding to 10 Hz EEG resonance frequency. The range $l = 2 - 4 \mu\text{m}$ was mentioned in [I59] as a lower bound for the length of beating cilium, corresponds to 25-36 Hz frequency range. In the same source, 10-12 μm was reported as normal cilium length: it corresponds to pendulum frequency 15.8 Hz. Furthermore, the beating frequency was reported to depend only weakly on l so that the beating frequency and pendulum frequency cannot be identified.

The estimates for the period of the cilium as gravitational pendulum correspond to EEG frequencies as also in the frequency range of beating waves. For $h_{eff} = \hbar_{gr} = GMm/v_0$ and m equal to proton mass, the corresponding transition energies are in the eV scale of biophotons for protons. What puts the bells ringing is that for electrons the energy scale is the same as that of the electronic metabolic energy quantum.

- (c) As a 2-D gravitational pendulum cilium can also rotate. Angular momentum is quantized as units $h_{eff} = \hbar_{gr}$. Electronic metabolic energy quanta can induce transitions between the harmonic oscillator states of the cilium. The transitions between the states of the quantum gravitational pendulum changing angular momentum would serve as the quantum counterpart for the torque in the models of Prakash *et al.* They would represent the quantum control by MB by using the transformation of gravitationally dark electrons to ordinary electrons.

Correlation between the height of the tissue and membrane potential of cilium

The height h of the tissue is interpreted as a parameter analogous to membrane potential.

- (a) TGD suggests that the membrane potential of cilium is proportional to the h . The critical height h_{cr} would correspond to a critical value V_{cr} of the ciliary membrane potential for the generation of miniature potential reducing V_{cr} .
- (b) Cilium as a gravitational pendulum is free when its distance from the surface is larger than the pendulum length l so that $h_{cr} = l$ is a natural identification. When the adhesion occurs MB induces a burst of miniature potentials $\Delta V = .5 \text{ meV}$ feeding electronic metabolic energy quanta to the cilium to achieve de-adhesion.

What happens in the adhesion and de-adhesion?

The key step of the process is the adhesion of cilia to the substrate and its reversal. The probability for the adhesion depends on the tissue height h and obviously vanishes for $h > l$, l the length of cilium. For very small h the cilium sticks on the surface. Part of the cilium would stick to the surface horizontally. Effective adhesion energy is assumed to be in a crucial role. The control action of the cell (animal) is modelled as an external torque on cilium.

Adhesion can also mean that two neighboring cilia moving in opposite direction stick together.

- (a) In the TGD framework, the de-adhesion could be induced by a transformation of a suitable number of electronic metabolic energy quanta about $E_c = .25 \text{ meV}$ associated with single electron (cilia do not have mitochondria) to the kinetic energy of the cilium as a gravitational pendulum.

One can estimate the velocity v if the de-adhesion induced by a receipt of single metabolic energy quantum E_c from $mv^2/2 = E_c$. This gives $v \simeq 60 \mu \text{ m/s}$. The estimate looks rather reasonable. For the standard metabolic energy quantum $.5 \text{ eV}$, one would be $v \simeq 2.7 \text{ mm/s}$.

- (b) If momentum is conserved, the change of the horizontal momentum component for the cilia as a pendulum is compensated by the recoil momentum of the entire cell. This gives an estimate for the change ΔV of the velocity of the cell as $\Delta V \sim (m_c/M) \times v$.

Adhesion energy and de-adhesion as predecessor of nerve pulse generation

What the notion of effective adhesion energy could mean in the TGD Universe (note that adhesion energy as a term is misleading since it actually corresponds to adhesion energy per surface area).

- (a) A very naive order of magnitude estimate used in the modelling of wetting of a surface by water approximates adhesion energy density with the surface tension σ_w for water: $\sigma_w \simeq 7210^{-3} \text{ kg/s}^2$. This corresponds to an energy density per unit area $\epsilon = .5 \times 10^{-11} \text{ eV}/(\mu \text{ m})^2$. For the cilium with radius $r = .2 \mu \text{ m}$ attached vertically this would give $W = \sigma_w \pi r^2 \simeq .7 \times 10^{-12} \text{ eV}$. This is extremely small energy and looks unrealistic.
- (b) For instance, if chemical or other kinds of bonds are formed with the surface, the adhesion energy can be even in the eV range. TGD suggests the formation of flux tube bonds between cilia and surface is what comes into mind and the adhesion energy would correspond to the reduction of energy when the bond is formed and shortens by the reduction of h_{eff} as in the basic step of bio-catalysis.
- (c) The thermal stability of adhesion would suggest that the adhesion energy is of the order of thermal energy, which is of the order .05 eV, which is about 10 percent of the standard metabolic energy quantum. If this is the case, the size of .5 meV for the metabolic energy quantum of electron Cooper pairs implies that at least 100 dark gravitational electrons must transform to ordinary ones to liberate the cilium, which has stuck vertically. Recall that cilia can also stick to each other and the same estimate holds also now as a lower bound coming from the thermal stability of adhesion.
- (d) Intriguingly, the number of miniature potentials generated by acetylcholine vesicles needed to generate action potential is 100-200 (<https://cutt.ly/JD1ONEu>)! This suggests that the de-adhesion process is a predecessor for the generation of nerve pulse in the postsynaptic neuron. This conforms with the view that the ciliary membrane is a predecessor of axon.
- (e) Nerve pulse transmission connects the pre- and postsynaptic flux tubes to longer flux tubes and generates larger quantum coherent units. 100-200 miniature potentials generate an action potential after the connection has formed. What could be the counterpart of this at the level of cilia?

Intriguingly, the de-adhesion from the surface requires at least 100 miniature potentials in the model of cilium as a gravitational pendulum. Also the cilia of the neighboring cells can stick together if they move in opposite directions. De-adhesion would require roughly the same energy. Both mechanisms would generate the analog of nerve pulse.

Could the preneural system have transformed to a neural system by the evolution of single flagellum to axon? Could primary cilia have evolved to dendrites? Did flagella having even rather long lengths start to form permanent almost-contacts with the primary cilia of the neighboring cell or even more distant cells, which then developed to synaptic contacts. This would have required the evolution of cilia with radius below .5 μ to axon with radius about 2.5 μm , and containing axonal MTs instead of axonemal MTs. ATP based metabolism in the interior would have emerged besides electron based metabolism, and besides miniature potentials also action potentials and critical membrane potential would have emerged.

Do 'spikes' correspond to real spikes?

Spikes induced by a driving of an 'active-elastic' resonator define a key notion in the models of Prakash *et al.* The intuitive picture of the resonator is as a collection of cilia as motors connected by strings. The 'spikes' would be analogs of nerve pulses. 'Spikes' correspond to tugs inducing flocking and in neuroscience induce formation of larger coherent units of neurons.

In the TGD based model for nerve pulse, spike corresponds to a perturbation coming from MB and transforming the motion of a single pendulum from rotation to oscillation or vice versa. Same should be true now if the cilium is the predecessor of the axon.

- (a) The active-elastic resonator could correspond to cilia as quantum gravitational penduli and the temporary formation of flux tube connections between the MBs of the penduli could be a counterpart for the formation of strings.
- (b) A direct touch of cells is not necessary for a 'tug'. The touching of neighboring cilia might be enough and could be regarded as one particular case of adhesion and would be analogous to touch of pre- and postsynaptic cells mediated by the neurotransmitter vesicle. Since the distances between cells are measured in micrometers and if the ciliary lengths are about $100\ \mu$, this is possible.

In the TGD framework, one can consider the option that cilia do not even touch. Since quantum coherence is at the level of MBs, and what is needed in the TGD framework, is a reconnection of the U-shaped flux tubes associated with the cells: this is assumed to take place also in the synaptic contact in which neurons fused temporarily.

- (c) The probability for the reconnection of flux tubes (for the touching of cilia) increases as the cells approach each other and could lead to a fusion of several cellular MBs to a larger MB inducing a flock behavior controlled by the larger MB. This would take place when two neighboring ciliary gravitational penduli are in opposite phase with large enough amplitude so that they approach each other.
- (d) The propagation of nerve pulse would be a domino effect in which the adhesion of neighboring cells or adhesion of cell to surface followed by de-adhesion, which spoils synchronous motion locally and induces new adhesion. A multiple collision generating quantum coherent at the flux tube level would be in question.
- (e) In the collective mode the metabolic quanta E_c from cells would arrive in synchrony (but with time lapse to give rise to a wave) so that the cells would walk in synchrony. The rotation of the cilia as gravitational penduli with a constant phase difference gives rise to a wave. In this macroscopic gravitational quantum state *Trichoplax* would walk. Walking involves gravitation in an essential manner so that the appearance of quantum gravitation is not surprising.

The generation of propagating waves

The model for the generation of propagating waves is very much analogous to the model of axonal membrane as Josephson junction [K96, K44, K98] [L100, L104]. The oscillating waves for the phase differences of the Cooper pair wave function over Josephson junction define a dynamics analogous to that to a sequence of gravitational penduli. This model could apply as such at the level of ciliary membrane serving as a pre-axon.

The local motion could correspond to oscillation or rotation and the analog of nerve pulse would mean local transformation of oscillation to rotation or vice versa generating soliton or defect of soliton sequence locally.

Also waves that propagate at the level of the entire animal are involved and can be associated with a system of genuine gravitational penduli forming a planar structure. There would also be a propagating wave at the larger MB induced by the temporary fusion of MBs of cilia.

- (a) The local oscillation of the cilium takes place with the frequency $f = \sqrt{g/l}/2\pi$ of the gravitational pendulum. For the propagating wave $u = \omega t$ is replaced with $\omega(t - x/V)$. The rotation of the pendulum in a vertical rotation plane does not make sense but there are also modes in which the pendulum rotates in plane and have angular momentum which is large since one has $h_{eff} = h_{gr}$ serves as the unit of angular momentum. These modes would be crucial for the control of the motion.

The speed V of the wave would be analogous to a conduction velocity of nerve pulse. The first guess for the velocity would be as the velocity $V \sim (m_c/M) \times v$, where v is the horizontal velocity gained by the cilium de-attachment already estimated, and m_c and M are the masses of cilium and cell.

- (b) If one or more metabolic energy quanta E_c feed energy to a single pendulum, the pendulum ceases to be in phase with its neighbors. If the same takes place for MBs, they might reconnect. Could a phase transition initiated by a seed at the level of MBs generate a larger quantum coherent unit analogous to a moving vortex? Energy cascade would correspond to BSFR with time reversal.

Flocking as a generation of quantum gravitational coherence

What could the formation of collective modes, flocking, mean in the TGD framework?

- (a) The modes of a single cilium correspond to a sticking to the plane without motion, rotation around a roughly elliptical orbit in plane, and rotation without motion. If a single cilium behaves as a solid body, one has a vortex- like structure rotating like a rigid body. Note however that Trichoplax can be very far from a rigid body: it can even split into two parts.
- (b) The quantal description of the cilia as a quantum gravitational pendulum combined with the conservation of angular momentum suggests that the angular momentum for the center of mass motion of the Trichoplax and the total angular momentum of the ciliary oscillators sum up to zero. This would explain the nearly circular motions. Linear motion of Trichoplax would correspond to a common vertical rotation plane without rotation.

In fact, both momentum and angular momentum generation could rely on conservation laws and reduce to exchanges of these conserved quantities between MB and system. This seems to be the only option since metabolic energy quanta with $h_{eff} = h$ cannot create forces and torques in the scale of an organism.

It deserves to be mentioned that the generation of angular momentum of astrophysical objects such as galaxies is poorly understood in the general relativistic framework and the TGD proposal is that the angular momentum of visible matter is accompanied by opposite angular momentum of dark matter and magnetic bodies of astrophysical objects [L83].

- (c) This model would realize the fractal aspect of holography: the ciliary motion would correspond to the motion of the entire animal. Second aspect of holography is that 3-D data fix the time evolution in the sense that the orbits are analogous to Bohr orbits. In TGD, this is forced by the realization of the general coordinate invariance, and means that the 3-D surface of $H = M^4 \times CP_2$ is almost uniquely determined by a 3-D surface without any data about its 4-D tangent space. Also this aspect of holography is realized and could explain why such an extremely simple model can describe the motion of Trichoplax.
- (d) Moving vortex-like defects could correspond to the formation of quantum coherent states in which cilia as gravitational penduli are in the same quantum state with non-vanishing angular momentum and non-trivial center-of-mass motion. There is also an analogy with the decomposition of the rotational motion to vortices in super-fluidity.

How could a living system direct its attention?

Prakash *et al* [I165, I163, I164] also found that Trichoplax can also react in a selective manner to perturbations as if it could direct its attention.

According to the TGD inspired theory of consciousness, a metabolic energy feed to the target of attention serves as a correlate for the directed attention. The target corresponds to

a mental image of the MB of the system. Mental images have correlates at the level of the space-time surfaces. Space-time surfaces are minimal surfaces with singularities analogous to soap films with frames [L121]. At the frames the dynamics fail to be completely deterministic so that they naturally serve as space-time correlates of mental images. The non-determinism is also finite.

This mental image 'wakes up' in a BSFR separating it from the environment and the superposition of 4-D soap films is reduced so that a single alternative from a finite number of time evolutions is selected. This explains the mysterious looking discovery that during intensive discussion almost anything can happen in the background and remain unnoticed. Sensory input does not lead to a wake up of mental image. The behaviour of the Trichoplax is completely analogous to the behaviour of higher life forms.

14.4.5 Possible implications of the notion of pre-CNS

The notion of pre-CNS is very general and it is interesting to consider the most obvious implications.

Can organisms without CNS learn?

In [I141] the question whether learning without the nervous system is impossible is considered. Computers are left out of consideration and this restricts the discussion to organic matter. One can consider several definitions for learning. If the change in behaviour is taken as a signature of learning, one ends up to the conclusion that there are large classes of organisms without nervous systems, which are able to learn: paramecia, bacteria and plants are three large classes of this kind of organisms.

There is evidence that multi-cellulars have evolved from the colonies of mono-cellulars, and it is known that colonies of bacteria learn [I152] (<https://cutt.ly/zD0vhuN>). For instance, *E. Coli* colonies can anticipate changes in the environment by associating higher temperatures with a lack of oxygen. This is the basic type of learning in neural systems and interpreted in terms of changes of synaptic strengths.

Animals with ciliary systems have pre-CNS in the proposed sense, and could learn by essentially the same mechanisms as neuronal networks. Associative learning involves a strengthening of synaptic contacts increasing the probability for the formation of transmitter vesicles. Now this would mean the increase of the probability for the formation of a 'tug' contact and this would lead to the analogs of sub-neural networks.

The model of genetic code based on bioharmony [L22, L96, L108, L141] leads to the proposal that the basic mechanism of learning emerge already at the level of basic biomolecules DNA, RNA, tRNA, and amino acids (AA). Bioharmonies define different moods and the learning by conditioning involves in an essential manner moods affected by the stimulus already at the molecular level. The basic moods would be realized already at the level of basic biomolecules $X = \text{DNA, RNA, tRNA, AAs}$, or rather, the pairings $DX-X$ where DX is the dark analog of X identified as dark nucleon sequence [L141]. Epigenetic mechanisms could stabilize the bioharmonies as correlates for the moods.

There is experimental evidence for this kind of learning (<https://cutt.ly/6SuLNqk>). When the RNA of an animal, which has learned a conditioned behavior, is scattered on the neurons of the animal that has not learned the behavior, the neurons so the signatures of learned behavior. Somehow the RNA transmits the conditioning based on negative or positive emotions generated by the stimulus. The explanation terms of DRNA-RNA pairing carrying the mood infecting the neurons with the conditioned behavior is discussed in the TGD framework in [L69, L85].

Also plants have senses and motor actions

Also plants have senses (<https://cutt.ly/mD0A9Zo>) and motor actions (for instance, sun flower orients itself towards Sun) and can learn (<https://cutt.ly/sD0PUZo>).

Can the proposed general model for pre-CNS explain these findings?

- (a) Microtubules are essential for cilia and axons. In general, plant cells do not have centriole or flagella: the motile, freely swimming sperm cells of some plants are an exception.

Plants however have root hair (<https://cutt.ly/JD0A7rc>) consisting of epidermal cells having lateral tubular extensions resembling cilia. Their radius varies between 17-17 μm and the length varies between 80-1,500 μm so that their scale is roughly 100 times larger than that of cilia. The basic function of root-hair cells is to collect water and nutrients from the soil.

- (b) The MBs of root-hair cells controlling them must be able to receive sensory input from root-hair cells and control their activities. Essentially the same general model seems to work as in the case of axons and cilia.

The membranes of root-hair cells could serve as sensory receptors using Josephson radiation to communicate the sensory input to MB. Root hair cells do not contain chloroplasts nor do they perform photosynthesis, which suggests that also now the electronic variant of metabolism is involved. The miniature potentials would appear as analogs of nerve pulses.

Some parts in the stem of the plant can be surrounded by hairy extensions which consist of a single cell or are multicellular structures. Also these could serve as sensory receptors. Note that the hairy geometry would maximize the sensory area.

- (c) What about the counterpart of the neuron network? Although plant cells are covered by cell walls composed of cellulose, hemicelluloses and pectin, they are not completely isolated. Plasmodesma (<https://cutt.ly/9D0Sraf>) are gap junction-like connections between neighboring plant cells, which allow the transfer of molecules. Plasmodesma could also act as analogs of permanent synaptic contacts, something which brings in mind a meridian system. Note that plasmodesma also have MTs as components.
- (d) Plants communicate with each other [I80] (<https://cutt.ly/PD0Sies>), for instance via their roots send signals to each other under the soil by using chemical secretions.

In the TGD Universe, the communications mediated by dark photon signalling via the layers of MB could make indirect communications possible. Plants form communities (<https://cutt.ly/eD0Sf0F>). One can even ask whether for instance a crop field or wood resembling a ciliary community covering a cell membrane could give rise to a higher level nervous system of some kind.

Talking fungi

After having written this article I learned of a fascinating discovery of Andrew Adamatsky [I52], who has studied sponges and found that they show electrical activity sequences of analogs of action potentials ('spikes').

The abstract of the article gives an overview about the findings.

*Fungi exhibit oscillations of extracellular electrical potential recorded via differential electrodes inserted into a substrate colonised by mycelium or directly into sporocarps. We analysed electrical activity of ghost fungi (*Omphalotus nidiformis*), Enoki fungi (*Flammulina velutipes*), split gill fungi (*Schizophyllum commune*) and caterpillar fungi (*Cordyceps militari*). The spiking characteristics are species specific: a spike duration varies from one to 21 hours and an amplitude from 0.03 mV to 2.1 mV.*

*We found that spikes are often clustered into trains. Assuming that spikes of electrical activity are used by fungi to communicate and process information in mycelium networks, we group spikes into words and provide a linguistic and information complexity analysis of the fungal spiking activity. We demonstrate that distributions of fungal word lengths match that of human languages. We also construct algorithmic and Liz-Zempel complexity hierarchies of fungal sentences and show that species *S. commune* generate most complex sentences*

The amplitude of spikes varies in the range .03- 2.1 meV. The analogs of miniature potentials correspond to energy .4 meV. The prediction of the TGD based model for the metabolic energy quantum for electron triplet is .51 meV. The solar gravitational metabolism associated with photosynthesis would correspond to the upper bound of 2.5 meV for the metabolic energy. The natural question is whether this kind of communication is specific to fungi or occurs also in preunoral and neuronal systems in general.

The language hypothesis conforms with the TGD based view that the dark variants of genetic code realized using as codons dark photon triplets analogous to 3-chords defining what I call bioharmony serving as a correlate for emotional state and fundamental level [L108, L141]. Dark 3N-photons as representation of for instance genes, define analogs of music pieces. For the TGD based view of the emergence of human language see [K147]. Genetic code would have number theoretic and geometric origin and would be universal. It would have several realizations and be realized also in other than biological systems.

Dark 3N-photons are analogous to Bose-Einstein condensate of 3N-photons and correspond to so-called Galois singlets, whose formation would rely on a universal number theoretical mechanism for the formation of bound states. The sequence of dark codons selects the receiver, which must possess the same sequence of dark nucleon triplets to achieve resonance. If the frequency scale is modulated, the reception generates a sequence of 3N-pulses analogous to nerve pulse sequence and in this way transforms information coded to frequency modulation to a pulse sequence.

14.5 Are space-time boundaries possible in the TGD framework?

One of the key ideas of TGD from the very beginning was that the space-time surface has boundaries and we see them directly as boundaries of physical objects.

It however turned out that it is not at all clear whether the boundary conditions stating that no isometry currents flow out of the boundary, can be satisfied. Therefore the cautious conclusion was that perhaps the boundaries are only apparent. For instance, the space-time regions correspond to maps $M^4 \rightarrow CP_2$, which are many-valued and have as turning points, which have 3-D projections to M^4 . The boundary surfaces between regions with Minkowskian and Euclidean signatures of the induced metric seem to be unavoidable, at least those assignable to deformations of CP_2 type extremals assignable to wormhole contacts.

There are good reasons to expect that the possible boundaries are light-like and possibly also satisfy the $\det(g_4) = 0$ condition and I have considered the boundary conditions but have not been able to make definite conclusions about how they could be realized.

- (a) The action principle defining space-times as 4-surfaces in $H = M^4 \times CP_2$ as preferred extremals contains a 4-D volume term and the Kähler action plus possible boundary term if boundaries are possible at all. This action would give rise to a boundary term

representing a normal flow of isometry currents through the boundary. These currents should vanish.

- (b) There could also be a 3-D boundary part in the action but if the boundary is light-like, it cannot depend on the induced metric. The Chern-Simons term for the Kähler action is the natural choice. Twistor lift suggests that it is present also in M^4 degrees of freedom. Topological field theories utilizing Chern-Simons type actions are standard in condensed matter physics, in particular in the description of anyonic systems, so that the proposal is not so radical as one might think. One might even argue that in anyonic systems, the fundamental dynamics of the space-time surface is not masked by the information loss caused by the approximations leading to the field theory limit of TGD.

Boundary conditions would state that the normal components of the isometry currents are equal to the divergences of Chern-Simons currents and in this way guarantee conservation laws. In CP_2 degrees of freedom the conditions would be for color currents and in M^4 degrees of freedom for 4-momentum currents.

- (c) This picture would conform with the general view of TGD. In zero energy ontology (ZEO) [L89, L112] phase transitions would be induced by macroscopic quantum jumps at the level of the magnetic body (MB) of the system. In ZEO, they would have as geometric correlates classical deterministic time evolutions of space-time surface leading from the initial to the final state [L82]. The findings of Mineev et al provide [L82] lend support for this picture.

14.5.1 Light-like 3-surfaces from $\det(g_4) = 0$ condition

How the light-like 3- surfaces could be realized?

- (a) A very general condition considered already earlier is the condition $\det(g_4) = 0$ at the light-like 4-surface. This condition means that the tangent space of X^4 becomes metrically 3-D and the tangent space of X^3 becomes metrically 2-D. In the local light-like coordinates, (u, v, W, \bar{W}) $g_{uv} = g_{vu}$ would vanish (g_{uu} and g_{vv} vanish by definition. Could $\det(g_4) = 0$ and $\det(g_3) = 0$ condition implied by it allow a universal solution of the boundary conditions? Could the vanishing of these dimensional quantities be enough for the extended conformal invariance?

- (b) 3-surfaces with $\det(g_4) = 0$ could represent boundaries between space-time regions with Minkowskian and Euclidean signatures or genuine boundaries of Minkowskian regions.

A highly attractive option is that what we identify the boundaries of physical objects are indeed genuine space-time boundaries so that we would directly see the space-time topology. This was the original vision. Later I became cautious with this interpretation since it seemed difficult to realize, or rather to understand, the boundary conditions.

The proposal that the outer boundaries of different phases and even molecules make sense and correspond to 3-D membrane like entities [L121], served as a partial inspiration for this article but this proposal is not equivalent with the proposal that light-like boundaries defining genuine space-time boundaries can carry isometry charges and fermions.

- (c) How does this relate to $M^8 - H$ duality [L90, L91]? At the level of rational polynomials P determined 4-surfaces at the level of M^8 as their "roots" and the roots are mass shells. The points of M^4 have interpretation as momenta and would have values, which are algebraic integers in the extension of rationals defined by P .

Nothing prevents from posing the additional condition that the region of $H^3 \subset M^4 \subset M^8$ is finite and has a boundary. For instance, fundamental regions of tessellations defining hyperbolic manifolds (one of them appears in the model of the genetic code [L108]) could be considered. $M^8 - H$ duality would give rise to holography associating

to these 3-surfaces space-time surfaces in H as minimal surfaces with singularities as 4-D analogies to soap films with frames.

The generalization of the Fermi torus and its boundary (usually called Fermi sphere) as the counterpart of unit cell for a condensed matter cubic lattice to a fundamental region of a tessellation of hyperbolic space H^3 acting is discussed in [L123]. The number of tessellations is infinite and the properties of the hyperbolic manifolds of the "unit cells" are fascinating. For instance, their volumes define topological invariants and hyperbolic volumes for knot complements serve as knot invariants.

This picture resonates with an old guiding vision about TGD as an almost topological quantum field theory (QFT) [K60, K11, K144], which I have even regarded as a third strand in the 3-braid formed by the basic ideas of TGD based on geometry-number theory-topology trinity.

- (a) Kähler Chern-Simons form, also identifiable as a boundary term to which the instanton density of Kähler form reduces, defines an analog of topological QFT.
- (b) In the recent case the metric is however present via boundary conditions and in the dynamics in the interior of the space-time surface. However, the preferred extremal property essential for geometry-number theory duality transforms geometric invariants to topological invariants. Minimal surface property means that the dynamics of volume and Kähler action decouple outside the singularities, where minimal surface property fails. Coupling constants are present in the dynamics only at these lower-D singularities defining the analogs of frames of a 4-D soap film.

Singularities also include string worlds sheets and partonic 2-surfaces. Partonic two-surfaces play the role of topological vertices and string world sheets couple partonic 2-orbits to a network. It is indeed known that the volume of a minimal surface can be regarded as a homological invariant.

- (c) If the 3-surfaces assignable to the mass shells H^3 define unit cells of hyperbolic tessellations and therefore hyperbolic manifolds, they also define topological invariants. Whether also string world sheets could define topological invariants is an interesting question.

14.5.2 Can one allow macroscopic Euclidean space-time regions

Euclidean space-time regions are not allowed in General Relativity. Can one allow them in TGD?

- (a) CP_2 extremals with a Euclidean induced metric and serving as correlates of elementary particles are basic pieces of TGD vision. The quantum numbers of fundamental fermions would reside at the light-like orbit of 2-D wormhole throat forming a boundary between Minkowskian space-time sheet and Euclidean wormhole contact- parton as I have called it. More precisely, fermionic quantum numbers would flow at the 1-D ends of 2-D string world sheets connecting the orbits of partonic 2-surfaces. The signature of the 4-metric would change at it.
- (b) It is difficult to invent any mathematical reason for excluding even macroscopic surfaces with Euclidean signature or even deformations of CP_2 type extremals with a macroscopic size. The simplest deformation of Minkowski space is to a flat Euclidean space as a warping of the canonical embedding $M^4 \subset M^4 \times S^1$ changing its signature.
- (c) I have wondered whether space-time sheets with an Euclidean signature could give rise to black-hole like entities. One possibility is that the TGD variants of blackhole-like objects have a space-time sheet which has, besides the counterpart of the ordinary horizon, an additional inner horizon at which the signature changes to the Euclidean one. This could take place already at Schwarzschild radius if g_{rr} component of the metric does not change its sign.

14.5.3 But are the normal components of isometry currents finite?

Whether this scenario works depends on whether the normal components for the isometry currents are finite.

- (a) $\det(g_4) = 0$ condition gives boundaries of Euclidean and Minkowskian regions as 3-D light-like minimal surfaces. There would be no scales in accordance with generalized conformal invariance. g_{uv} in light-cone coordinates for M^2 vanishes and implies the vanishing of $\det(g_4)$ and light-likeness of the 3-surface.

What is important is that the formation of these regions would be unavoidable and they would be stable against perturbations.

- (b) $g^{uv}\sqrt{|g_4|}$ is finite if $\det(g_4) = 0$ condition is satisfied, otherwise it diverges. The terms $g^{ui}\partial_i h^k\sqrt{|g_4|}$ must be finite. $g^{ui} = \text{cof}(g_{iu})/\det(g_4)$ is finite since $g_{uv}g_{vu}$ in the cofactor cancels it from the determinant in the expression of g^{ui} . The presence of $\sqrt{|g_4|}$ implies that the these contributions to the boundary conditions vanish. Therefore only the condition boundary condition for g^{uv} remains.
- (c) If also Kähler action is present, the conditions are modified by replacing $T^{uk} = g^{u\alpha}\partial_\alpha h^k\sqrt{|g_4|}$ with a more general expression containing also the contribution of Kähler action. I have discussed the details of the variational problem in [K18, K11].

The Kähler contribution involves the analogy of Maxwell's energy momentum tensor, which comes from the variation of the induced metric and involves sum of terms proportional to $J_{\alpha\mu}J_\mu^{\beta\alpha}$ and $g^{\alpha\beta}J^{\mu\nu}J_{\mu\nu}$.

In the first term, the dangerous index raisings by g^{uv} appear 3 times. The most dangerous term is given by $J^{uv}J_v^v\sqrt{|g|} = g^{u\mu}g^{v\nu}J_{\alpha\beta}g^{vu}J_{vu}\sqrt{|g|}$. The divergent part is $g^{uv}g^{vu}J_{uv}g^{vu}J_{vu}\sqrt{|g|}$. The diverging g^{uv} appears 3 times and $J_{uv} = 0$ condition eliminates two of these. $g^{vu}\sqrt{|g|}$ is finite by $\sqrt{|g|} = 0$ condition. $J_{uv} = 0$ guarantees also the finiteness of the most dangerous part in $g^{\alpha\beta}J^{\mu\nu}J_{\mu\nu}\sqrt{|g|}$.

There is also an additional term coming from the variation of the induced Kähler form. This to the normal component of the isometry current is proportional to the quantity $J^{\alpha\mu}J_\mu^k\partial_\beta h^l\sqrt{|g|}$. Also now, the most singular term in $J^{u\beta} = g^{u\mu}g^{\beta\nu}J_{\mu\nu}$ corresponds to J^{uv} giving $g^{uv}g^{vu}J^{uv}\sqrt{|g|}$. This term is finite by $J_{uv} = 0$ condition.

Therefore the boundary conditions are well-defined but only because $\det(g_4) = 0$ condition is assumed.

- (d) Twistor lift strongly suggests that the assignment of the analogy of Kähler action also to M^4 and also this would contribute. All terms are finite if $\det(g_4) = 0$ condition is satisfied.
- (e) The isometry currents in the normal direction must be equal to the divergences of the corresponding currents assignable to the Chern-Simons action at the boundary so that the flow of isometry charges to the boundary would go to the Chern-Simons isometry charges at the boundary.

If the Chern-Simons term is absent, one expects that the boundary condition reduces to $\partial_v h^k = 0$. This would make X^3 2-dimensional so that Chern-Simons term is necessary. Note that light-likeness does not force the M^4 projection to be light-like so that the expansion of X^2 need not take with light-velocity. If CP_2 complex coordinates are holomorphic functions of W depending also on $U = v$ as a parameter, extended conformal invariance is obtained.

14.5.4 $\det(g_4) = 0$ condition as a realization of quantum criticality

Quantum criticality is the basic dynamical principle of quantum TGD. What led to its discovery was the question "How to make TGD unique?". TGD has a single coupling

constant, Kähler couplings strength, which is analogous to a critical temperature. The idea was obvious: require quantum criticality. This predicts a spectrum of critical values for the Kähler coupling strength. Quantum criticality would make the TGD Universe maximally complex. Concerning living matter, quantum critical dynamics is ideal since it makes the system maximally sensitive and maximally reactive.

Concerning the realization of quantum criticality, it became gradually clear that the conformal invariance accompanying 2-D criticality, must be generalized. This led to the proposal that super symplectic symmetries, extended isometries and conformal symmetries of the metrically 2-D boundary of lightcone of M^4 , and the extension of the Kac-Moody symmetries associated with the light-like boundaries of deformed CP_2 type extremals should act as symmetries of TGD extending the conformal symmetries of 2-D conformal symmetries. These huge infinite-D symmetries are also required by the existence of the Kähler geometry of WCW [K60, K32, K102] [L116, L142].

However, the question whether light-like boundaries of 3-surfaces with scale larger than CP_2 are possible, remained an open question. On the basis of preceding arguments, the answer seems to be affirmative and one can ask for the implications.

- (a) At M^8 level, the concrete realization of holography would involve two ingredients. The intersections of the space-time surface with the mass shells H^3 with mass squared value determined as the roots of polynomials P and the light-like 3-surfaces as $\det(g_4) = 0$ surfaces as boundaries (genuine or between Minkowskian and Euclidean regions) associated by $M^8 - H$ duality to 4-surface of M^8 having associative normal space, which contains commutative 2-D subspace at each point. This would make possible both holography and $M^8 - H$ duality.

Note that the identification of the algebraic geometric characteristics of the counterpart of $\det(g_4) = 0$ surface at the level of H remains still open.

Since holography determines the dynamics in the interior of the space-time surface from the boundary conditions, the classical dynamics can be said to be critical also in the interior.

- (b) Quantum criticality means ability to self-organize. Number theoretical evolution allows us to identify evolution as an increase of the algebraic complexity. The increase of the degree n of polynomial P serves as a measure for this. $n = h_{eff}/h_0$ also serves as a measure for the scale of quantum coherence, and dark matter as phases of matter would be characterized by the value of n .
- (c) The 3-D boundaries would be places where quantum criticality prevails. Therefore they would be ideal seats for the development of life. The proposal that the phase boundaries between water and ice serve as seats for the evolution of prebiotic life, is discussed from the point of TGD based view of quantum gravitation involving huge value of gravitational Planck constant $\hbar_{eff} = \hbar_{gr} = GMm/v_0$ making possible quantum coherence in astrophysical scales [L125]. Density fluctuations would play an essential role, and this would mean that the volume enclosed by the 2-D M^4 projection of the space-time boundary would fluctuate. Note that these fluctuations are possible also at the level of the field body and magnetic body.
- (d) It has been said that boundaries, where the nervous system is located, distinguishes living systems from inanimate ones. One might even say that holography based on $\det(g_4) = 0$ condition realizes nervous systems in a universal manner.
- (e) I have considered several variants for the holography in the TGD framework, in particular strong form of holography (SH). SH would mean that either the light-like 3-surfaces or the 3-surfaces at the ends of the causal diamond (CD) determine the space-time surface so that the 2-D intersections of the 3-D ends of the space-time surface with its light-like boundaries would determine the physics.

This condition is perhaps too strong but a fascinating, weaker, possibility is that the internal consistency requires that the intersections of the 3-surface with the mass shells

H^3 are identifiable as fundamental domains for the coset spaces $SO(1,3)/\Gamma$ defining tessellations of H^3 and hyperbolic manifolds. This would conform nicely with the TGD inspired model of genetic code [L108].

14.6 Krebs cycle from TGD point of view

This section was inspired by the YouTube video (<https://cutt.ly/7XTY1Cc>) in which biologist Nick Lane talked of Krebs cycle, also known as citric acid cycle, (<https://cutt.ly/kXTY9B5>). The title of the video was "How the Krebs cycle powers life and death?". I am grateful for Marko Manninen for the link.

14.6.1 Lane's view of the role of Krebs cycle in the emergence of life

Lane's talk starts with a picture about the network of metabolic reaction pathways of an animal cell. Its complexity is absolutely stunning. In the network nodes correspond to various biochemical compounds and edges between them to reactions catalyzed by biocatalyst.

This huge complexity shows how magnificent work biochemists have done but also forces, at least me, to ask whether there should exist a description relying on deeper principles and involving something beyond chemistry.

Before continuing, I can of course reveal the cards already now and tell that I have been working for roughly two decades with what I could call TGD (Topological Geometro-dynamics) [L116] inspired quantum biology. Quantum gravitation in the TGD sense and phases of ordinary matter, which can be quantum coherent in arbitrarily long length scales and behave in many respects like dark matter, play a crucial role in this model. The model challenges the vision of life as nothing but biochemistry.

Krebs cycle

In the middle of the illustration of the metabolic network stands the Krebs cycle. There is in fact also another cycle found by Krebs: readers can try to identify it from the picture of the video.

- (a) The input of the cycle is glucose C_6H_{12} produced in previous reactions splitting carbohydrates, proteins and lipids. Glucose is first split into pyruvate involving 2 carbon atoms. This produces carbon dioxide CO_2 , which can be said to be a waste product. Second output of the cycle is water H_2O .
- (b) The Krebs cycle has two basic functions. The first function is to build precursors of various biomolecules like amino acids, nucleotides, and lipids for further processing in the other parts of the reaction pathway network.

Second function is to liberate the metabolic energy of the pyruvate. Mitochondria, where Krebs cycle takes place are both power stations and molecular factories of the cell building the basic building blocks constructed in other parts of the cell.

- (c) Although CO_2 and H_2O can be said to be the outputs of the aerobic Krebs cycle, Lane prefers to talk about $2H$ as the output. The pairs $2H$ react with NAD^+ to give $NADH + H^+$. The reaction liberates energy kicking the proton H^+ over the potential wall defined by the membrane voltage.

Eventually the proton falls back and gains energy by acceleration in the electric field: the energy of the proton makes possible the energization of ADP by phosphorylation: $ADP \rightarrow ATP$ adding one phosphate P_i to ADP. $ATP \rightarrow ADP$ in turn takes care of the further distribution of the metabolic energy. One can say that ATP serves as a basic metabolic currency and all biological processes use this standard coin. Note that

Krebs cycle has both aerobic and anaerobic variants and only the last step involves oxidative phosphorylation.

NADH, which has taken hydrogen and one electron e^- of $2H$ carries the electron to electron chain in which electrons are transferred in a stepwise manner along the mitochondrial membrane and gradually gives up its energy and end up to oxygen and ADP.

- (d) Krebs cycle is indeed a cycle. At the first step it transforms pyruvate involving two C atoms to a compound with 6 C atoms and and at the first half of the cycle it is transformed to a compound with 4 C atoms going through 4 steps being eventually transformed to the compound with 6 C atoms.

Reverse Krebs cycle

In the reverse Krebs cycle (<https://cutt.ly/HXTY5RR>, CO_2 and $2H$ and energy are the inputs and pyruvate is the output. Also reactions like $NAD^+ + 2H \rightarrow NADH + H^+$ are reverted so that a time reversal at some level is suggestive. Instead of production of ATP, ATP is used to get energy in absence of some other energy source such as solar radiation. The symmetry between the two halves of the Krebs cycle allows the production of the precursors of various biomolecules also in the reverse Krebs cycle.

- (a) Reverse Krebs cycle is obviously a natural predecessor of the Krebs cycle, which appears when animals use the energy stored chemically by photosynthesizing organisms. Instead of photons, the reverse Krebs cycle can also use biochemical energy. Even electron energy can be used.
- (b) Photosynthesis relies on the reverse Krebs cycle used by plants and some other photosynthesizing organisms (algae living in oceans). Energy comes from photons of solar radiation and is stored in various biomolecules and ATP produced in the reverse Krebs cycle. The biomolecules storing energy are then used by animals using the Krebs cycle.
- (c) In the archaea and bacteria H_2O as input of reverse Krebs cycle can be replaced with H_2S . This can occur even in mammalian mitochondria under stress conditions, when oxygen supply is reduced (<https://cutt.ly/qXTUe4j>)
- (d) The Krebs cycle can be reversed under some conditions such as cancer. Lane argues that the reverted Krebs cycle is favourable for cancer cells since it produces basic precursors of the basic biomolecules. But also the Krebs cycle does this: maybe the reverse Krebs cycle does this more effectively. In any case, the reverse Krebs cycle does not liberate metabolic energy so that it has disastrous effects.
- (e) Some primitive life forms can use both Krebs cycle and reverse Krebs cycle, be animal- or plant-like, one might say.

The importance of charge separation

Lane emphasized the importance of charge separation. The interior of the cell is negatively charged and the outside positively charged. This charge separation is very common in living matter. For instance, DNA is negatively charged: one unit of negative charge per nucleotide associated with phosphate. Earth's interior is negatively charged and exterior positively charged.

Pollack effect [I126, I125, L25, ?, ?] generates negatively charge regions of water, exclusion zones with effective stoichiometry H_2O and layer like hexagonal structure consisting of hexagons. Clearly, the Pollack effect produces OH^- from H_2O molecules.

Pollack effect is induced by the irradiation of water in a presence of gel at visible or IR wavelengths and induces charge separation. This effect is poorly understood in the standard

chemistry framework and its explanation involving new physics is a central element in the TGD based view of living matter [L25].

Krebs cycle takes care of the charge separation requiring energy feed metabolic energy storage in the pyruvate.

The proposal for the evolution of life

Lane also discusses evolution of life starting from the idea that the primitive form of reverse Krebs cycle preceded the recent forms of life. It was discovered in 1966 that photosynthetic bacteria living in anaerobic environments use the reverse Krebs cycle to produce basic biomolecules and to store energy.

- (a) Margaret Dayhoff was the mother of bioinformatics. On the basis of the evolution of the present day form of enzyme ferredoxin, which has simple inorganic active site and has a key role in photon energy utilization, Dayhoff suggested that its prototype was incorporated into metabolism very early in biological evolution, even before genetic code existed(!). Ferredoxin was evolved by a doubling of a shorter protein, which would have evolved only 8 the simplest amino acids. This shorter ancestor in turn involves only amino acids alanine, proline, serine, and glycine.

For instance, methanogens (archaea) and acetogens (bacteria) use a simple analog of Krebs cycle to grow from H_2 and CO_2 by using a so-called COA pathway.

Reverse Krebs cycle is associated with anaerobic photosynthetic bacteria and since photosynthesis makes chemical energy storage possible, reverse Krebs cycle must have appeared first. Its analog can also use chemical energy of inorganic molecules.

- (b) Bill Martin proposed that so-called LUCA living in hydrothermal vents is the ancestor of bacteria and archaea (<https://cutt.ly/hXTUoZ6>). LUCA would have lived 4 billion years ago. LUCA was autotrophic and made all its biomolecules from the inorganic molecules of the environment containing hydrogen, CO_2 and nitrogen turning them to organic compounds like ammonia. It lived in the dark and there was no oxygen so that it would have obtained its metabolic energy from some other source than recent plants and animals.

It would have used the primitive version of the reverse Krebs cycle with H_2S and CO_2 as inputs to build basic biomolecules. This process is an analog of photosynthesis storing energy as chemical energy. Inorganic molecules would have replaced photons as the source of metabolic energy.

The genes of LUCA would have been very simple. The first naive guess is that the genes of LUCA are shared by archaea, prokaryotes, and eukaryotes and this gives constraints on the speculations concerning their genome. This gives however quite too high a number of candidates. The lateral transfer of genes must be taken into account. It implies that the common genes need not be possessed by LUCA. The outcome was a proposal involving 355 genes for LUCA. For instance, the genes responsible for the synthesis of nucleic acids and amino acids were missing. Also the genes needed to code complete ribosomes were missing.

- (c) Deborah Kelley discovered alkaline hydrothermal vents with charge separation between interior containing. They are rich in hydrogen gas. Hydrothermal vents were predicted by geologist Mike Russel based on the study of what looked like fossilized mineral sponges. The pores of this inorganic structure would have had OH^- ions in the interior and protons in the exterior. The walls would have contained FeS.

Lane suggests that inorganic pores inside the hydrothermal vents represent a candidate for a proto cell.

- (a) Lane emphasized the importance of the charge separation. The interior of both proto cell and its modern version must have been negatively charged (alkaline) whereas the exterior was positively charged. Lane notices that a similar charge separation also characterizes Earth interior and exterior: the electric field of Earth is made possible by this charge separation. What is amusing and thought provoking is that the strength of the electric field in lightning is the same as through the cell membrane! Could one see Earth itself as a giant cell? Did life proceed from long scales to short scales or vice versa?
- (b) A primitive predecessor of reverse Krebs cycle using perhaps H_2S and CO_2 instead of water would have generated the building bricks of chemical life. Oxidation of inorganic compounds such as iron ions could have served as the source of the metabolic energy.
- (c) Lane discusses a proposal for the steps leading to pyruvate from which the Krebs cycle starts from. Bound methanol from CO_2 . From this to pyruvate containing two carbons. This is realized in the lab. Also lipids would have been generated leading to the emergence of cell membranes.

It should be noticed in passing that in the experiments producing the basic biomolecules UV light is often needed: this is understandable since the scale of molecular energies is in visible and UV. The problem is that the recent life forms do not however utilize UV light.

- (d) These life forms would have lived in hydrothermal vents and would have disappeared as life based on photosynthesis generating oxygen emerged. All plant-like life forms not using photosynthesis would have disappeared in CE if they existed at all.

Oxygen based life would have been the winner since reverse Krebs cycle for photosynthesis is much more effective than for the variant of Krebs cycle using chemical energy. Also aerobic Krebs cycle is much more effective than that based on fermentation. The monocellular life forms, possibly using H_2S based metabolism, would have disappeared in CE when the oxygen levels in oceans would have increased dramatically.

- (e) Note that the same proposal for the proto cell could work if H_2O replaces H_2S if it is available. One can also make "What if?" question. Can one imagine that photons and oxygen were in some mysterious way available from the beginning.
- (f) The next revolution according to Lane would have been the emergence of photosynthesis as analog of reverse Krebs. H_2O would have replaced H_2S from water. $CO_2 + H_2 \rightarrow CH_2O + O_2$ became the basic reaction making possible the storage of metabolic energy to carbon compounds and producing the basic building blocks of biomolecules.

The Great oxidation event (GOE), estimated to have occurred for 2.4-2.2 billion years before the Cambrian explosion (CE), would have initiated a very slow oxidation of oceans and amplified in CE dramatically. This would explain why the fossils of life forms utilizing oxygen based photosynthesis are absent before CE.

The scenario however has problems.

- (a) The proposal is that metabolism came first. However, metabolism requires biocatalysts and their generation requires genes. If metabolism was miraculously possible without genes, how genes emerged from metabolism? All nothing-but-chemistry based views of the origin of life have hen-egg problems. Did the cell membrane emerge first? Did proteins or genes emerge first? Did proteins, DNA or RNA emerge first?

All these need each other in recent life, which leads to asking whether something much deeper emerged first or was present from the beginning at the level of fundamental physics. Could this something relate to the difference between in-organic and organic matter and to the incredible efficiency and precision of bio-catalysis? Does biophysics involve something totally new, not yet identified?

- (b) Did the GOE really happen? What is known of fossils suggests that it occurred in CE but how is this possible? Did oxygen rich oceans appear out of nowhere just like the complex multicellulars. Could one think that this somehow occurred and multicellular cells replaced the possibly existing life forms in hydrothermal vents at the surface of Earth using chemical energy as metabolic energy?
- (c) As Lane emphasizes, charge separation is crucial. Pollack effect induces it. We do not understand the Pollack effect in the standard biochemistry framework.

These objections give a good motivation for developing a TGD based view about Krebs cycle. This view is based on some basic ideas of TGD inspired quantum biology, quantum gravitational views of metabolism [L129] and evolution of life [L125], the TGD inspired view about how Pollack effect induces charge separations leading also to a view of genetic code realized in terms of both dark proton and dark photon triplets, the TGD proposal for what happened in Cambrian explosion in which oxygenated oceans and highly developed multicellulars emerged apparently out of nowhere [L68, L120, L105].

14.6.2 TGD view of Krebs cycle and early life

The TGD based view of life could have emerged from the problems of the view of Lane.

1. Brief overview of quantum TGD

TGD and TGD inspired theories of consciousness and quantum biology rely on a new view of space-time and quantum theory [L116].

- (a) In the original form TGD was proposed to be a geometrization of classical physics: the gauge fields of standard model and gravitational fields are geometrized in terms of the geometry of 8-D space $H = M^4 \times CP_2$ in which space-times are 4-D surfaces.

The new view of space-time leads to notions like topological field quantization. Maxwellian fields are replaced by topological field quanta such as magnetic flux quanta (tubes and sheets) and electric flux quanta which correspond to space-time surfaces of finite spatial size in H .

- (b) Later the geometrization program was extended to include entire quantum physics and was based on the notion of the "world of classical worlds" (WCW) consisting of 4-D surfaces identified as space-time surfaces in H , which are preferred extremals of action principle analogous to Bohr orbits.

Preferred extremal/Bohr orbit property leads naturally to holography which is not quite exact, which has important implications for quantum biology and understanding of cognition. This in turn leads to zero energy ontology (ZEO). Quantum states are not superpositions of 3-D surfaces but of 4-surfaces.

They are therefore quantum variants for analogs of deterministic time evolutions: functions, behaviors of computer programs. The notion of function is central in biology and neuroscience and would be also a central notion in fundamental quantum physics.

ZEO leads to a TGD inspired theory of consciousness as a generalization of quantum measurement theory solving its basic problem due to the conflict of the determinism of unitary time evolution with non-determinism of state function reduction. Quantum jump replaces the entire superposition of space-time surfaces with a new one rather than violating the deterministic time evolution of a given space-time surface. There are two causalities: this solves the basic problem of quantum measurement theory. There are also two times: the geometric time of a physicist and the subjective time as a sequence of quantum jumps.

This in turn leads to a new view about state function reductions (SFR): in ordinary "big" SFR the arrow of time changes whereas in "small" SFR as an analog of weak measurement it is not changed. The findings of Mineev et al [L82] provide direct support

for ZEO [L82]. Also the views about thermodynamics must be modified since the arrow of time can change. The implications are especially profound in biology.

- (c) Later came a generalization of the physics based on real numbers to what I call adelic physics [L55, L56]. Adeles are fusion of reals and p-adic number fields identified as correlates of cognition and intention. p-Adic number fields are completions of rationals just like real numbers. They allow an infinite number of extensions induced by algebraic extensions of rationals.

It is natural to interpret the hierarchies of extensions of rationals as evolutionary hierarchies and one can assign to extensions the value of effective Planck constant $h_{eff} = nh_0$ determined by their dimension. Also biological evolution reduces to the increase of algebraic complexity in a sequence of quantum jumps replacing zero energy state with a new one.

This framework led to $M^8 - H$ duality, which generalizes the momentum-position duality of wave mechanics. This duality provides two views of physics. The complexification M_c^8 of M^8 , as analog of complexified 8-D momentum space, has an interpretation as complexified octonions. At the level of M^8 the counterparts of 4-surfaces are determined by the roots of monomial polynomials P of a real argument and having integer coefficients. The roots of P correspond to, in general complex, mass squared values defining mass shells H^3 (hyperbolic spaces) in momentum space $M_c^4 \subset M_c^8$. The roots are algebraic numbers in an extension of rationals defined by P and the Galois group of P acts as symmetries of the theory.

These 3-D objects are continued by holography to 4-surfaces. The holographic dynamics is dictated by the condition that the normal space of the 4-surface is associative, that is quaternionic. The second condition is that the normal space contains commutative space (analogous to complex numbers). This guarantees that the normal space corresponds to a point of CP_2 and makes it possible to map these associative 4-surfaces to space-time surfaces in H .

Some basic ideas of TGD inspired quantum biology

Consider now some aspect of TGD inspired quantum biology relevant for what follows.

1. Dark matter and quantum biology

Basic prediction of the number theoretic vision of TGD is a hierarchy of dark matter phases labelled by $h_{eff} = nh_0$, where n is the dimension associated with the extension of rationals.

- (a) Dark matter in the TGD sense residing at monopole flux tubes is central for the TGD view of life. Also the electric flux quanta, which correspond to deformations of minimal surfaces of H with 2-D membrane-like projection to E^3 are expected to be important and accompany for instance, the lipid layers of cell membrane and boundaries between two phases. For instance, molecules could be accompanied by these kinds of membranes involving $h_{eff} > h$ phases. Dark variants of protons and electrons and perhaps also ions reside at the field equanta.
- (b) Large value of h_{eff}/h would mean high algebraic complexity and high "IQ" so that the magnetic body (MB) would naturally use the biological body as a motor instrument and sensory receptor.
- (c) There are reasons to believe that the value of h_{eff} correlates with the interactions mediated by the flux tubes. Gravitational Planck constant $\hbar_{hr} = GMm/\beta_0$, where $\beta_0 = v_0/c \leq 1$ defines a quantize velocity parameter, M corresponds to either Earth's or solar mass and m is mass of a particle, is determined by Equivalence Principle and would characterize gravitational flux tubes. \hbar_{gr} must be used in the condition $\hbar_{gr}/\hbar \geq 1$ is satisfied. This notion was originally introduced by Nottale [E2] and discussed from the TGD point in [K111, K85, K88].

This proposal generalizes to other interactions. The gravitational Compton length $\Lambda_{gr} = \hbar_{gr}/m = GM/v_0 = r_S/2\beta_0$, where r_S is Schwarzschild radius. For Earth this gives $\Lambda_{gr} = .45$ cm. This should be a fundamental biological and also hydrodynamical length scale [L125, L115] besides the corresponding length scale associated with the Sun.

- (d) Large values of h_{eff} , in particular \hbar_{gr} , mean the presence of long range quantum fluctuations serving as correlations for quantum criticality, which in the TGD Universe would accompany ordinary criticality. In living matter these fluctuations would be associated with the criticality with respect to melting/freezing and boiling/condensing. There would also be criticality around physiological temperature especially relevant to biological life [L125]. In these transitions, large density fluctuations take place and this leads to the TGD view about the role of quantum gravitation in biology and theory of conscious experience. Quantum gravitation would not be relevant in Planck scale but for Planck mass scale and appear in macroscopic scales longer than Λ_{gr} and even in the scale of Earth and even Sun.
- (e) One ends up with a quantum gravitational view of metabolism [L129] based on the proposal that both hydrogen bonds and valence bonds are accompanied by magnetic flux tubes and be characterized by even \hbar_{gr} and therefore can have very long lengths giving rise to quantum coherence in long scales. The delocalization of dark protons at gravitational flux tubes by the absorption of dark solar photons would be a central element and one can say that the gravitational flux tubes serve as gravitational batteries with the metabolic energy stored in the reduction of the gravitational binding energy. One also ends up with a vision of how the neural system evolved [L129].
- (f) Pollack effect [I126, I125, L25, ?, ?] is a central element in the TGD view of living matter [L25, L44, L92, L36]. What would happen is that in the presence of a gel phase, the irradiation by visible or IR light would generate the negatively charged exclusion zone (EZ) by kicking protons of H_2O to the flux tubes of the MB of water where they could form sequences of dark protons.
Pollack effect would thus explain charge separation occurring for cell and DNA and even for Earth and would be absolutely central for TGD. A feed of metabolic energy would be necessary to preserve the charge separation requiring dark protons. An alternative interpretation is that preservation of high level of cognitive consciousness, measured by the value distribution of h_{eff} as analog of IQ, requires metabolic energy feed
- (g) Dark proton triplets or dark nucleon triplets [L141] at monopole flux tubes would provide a realization of the genetic code, and give rise to dark variants of DNA, RNA, tRNA and amino acids already at the level of water. Since also metabolism is involved.
- (h) The realization of the genetic code in terms of dark photon triplets would be essential for communications. The biochemical realization would be a secondary realization of the genetic code and would emerge later.
- (i) Number theoretic vision leads to a proposal that genetic code is universal [L108, L141]. Even the cell membrane could realize the genetic code. The key notion would be so-called icosahedron-tetrahedron tessellation at the hyperbolic space H^3 (mass shell and its counterpart in H) allowing realization of genetic code which would induce realizations at the space-time level. Also higher than 1-D realizations, such as realization at the level of cell membrane.

This picture would solve the hen-egg problems of the nothing-but-chemistry approach [L127]. All the basic building blocks necessitating each other emerge simultaneously. The TGD based view of space-time also strongly suggests that membrane-like structures are universal at the space-time level [L121] and are associated with cell membranes and various boundary layers.

2. Zero energy ontology

Zero energy ontology (ZEO) [L89, L112, L124] [K146] is also important for the TGD view of life.

- (a) "Big" or ordinary SFRs (BSFRs), would reverse the arrow of time and the interpretation of BSFR could be interpreted as a universal counterpart of death. BSFR would however mean reincarnation with an opposite arrow of time.
- (b) Sleep-awake cycle could be due to BSFRs at some level of MB. At the level of bio-molecules analogous cycles are also present. During the sleep period, dissipation occurs with a reverse arrow of time and this looks like healing when looked from the opposite time direction.

Since MB controls biological matter with $\hbar_{eff} = \hbar$, the change of the arrow of time in BSFRs at the level of the magnetic/field body would induce effective time reversal at the level of the ordinary biomatter. The arrow of time for ordinary matter would change in a very short time scale since BSFRs would occur with a high rate.

An attractive conjecture is that Krebs cycle and its reversal are time reversals of each other at some level of MB. If so, the appropriate levels of MBs of animals and plants tend to live in opposite time directions. As noticed, the Krebs cycle can change to its reversal, say in cancer, and the interpretation would be that the analog of cell death followed by a reincarnation with an opposite arrow of time occurs.

Expanding Earth hypothesis, Cambrian explosion, and emergence of oxygen rich oceans

The TGD proposal is that life and photosynthesis and higher chemical life emerged in underground oceans. Oxygen is needed and oxidation of the underground oceans would have taken place by photosynthesis by reverse Krebs cycle and been based on water instead of H_2S .

1. Evolution of life in underground oceans

Consider now the TGD picture.

- (a) Life would have evolved in underground oceans shielded from meteoritic bombardment and cosmic rays. The radius of Earth increased rapidly by a factor of about 2 during the Cambrian explosion (CE). The multicellular life utilizing photosynthesis bursted to the surface of Earth and formed recent oceans.

There would have been no oceans before the CE. Hydrothermal vents could have existed. The possible lifeforms were very simple bacteria, which photosynthesized using H_2S since there was now water and oxygen.

Earth was like Mars now: Mars has no oceans and no oxygen. There are indications of underground reservoirs of water and signs of simple life forms.

- (b) Cosmic expansion in GRT predicts astrophysical objects to expand smoothly. This does not happen. In the TGD Universe, the expansion would be a quantum phenomenon and take place in rapid jerks and such a jerk would have induced CE.

I got interested in the Expanding Earth hypothesis after watching a video [F9] by Neal Adams. The video is very impressive artwork but in the lack of references skeptics probably cannot avoid the feeling that Neal Adams might use his highly developed animation skills to cheat the reader. I found also a polemic article [F1] of Adams but the references were lacking. The basic argument was that the Wegener hypothesis generalizes. If the radius of the Earth were 1/2 of the recent radius, the whole Earth would be covered by continents fitting together along their boundaries.

2. Expanding Earth hypothesis

This leads to Expanding Earth Hypothesis (EEH) [L68, L120, L105].

- (a) EEH stating that the radius of Earth increased rather rapidly by a factor of about two in Cambrian Explosion and underground oceans serving as seats for highly evolved photosynthesizing life bursted to the surface and forming oceans.
- (b) Highly developed multicellular animals and photosynthesizing algae bursted to the surface. Note that algae are responsible for the production of most oxygen also in the recent oceans. If hydrothermal vents contained sulphur based life it disappeared because the generation of the basic building blocks of biomolecules was too slow.

Interestingly, the radius of Mars is roughly 1/2 of that for Earth. Could Mars have underground oceans teeming with life? When does the radius increase by factor two?

- (c) There is however a problem. How is photosynthesis possible underground? It is dark there! The basic proposal is that solar photons with energies in the visible and possibly infrared range arrive as dark photons along monopole flux tubes, which extend above the Earth and carry dark matter. The strength of the magnetic field would be about .2 Gauss and fraction 2/5 of the nominal value of the Earth's total magnetic field involving also a non-monopole part.
- (d) Also dark photons from the interior of Earth propagating along the flux tubes or associated with them could have served as an energy source. The temperature in the Earth's inner core (with radius about 20 percent of the Earth's radius) corresponds to about 5,500 K, which corresponds to a thermal energy scale of about .55 eV, which corresponds to the nominal value of the metabolic energy quantum.

The energy at the maximum of the energy distribution is roughly 3 times larger than this energy and would be around 1.65 eV. The energy at the maximum wavelength of thermal energy distribution is 5 times higher and about 2.75 eV, which is the upper bound for the energy range 2-2.75 eV of visible photons.

If the temperature of the inner core before CE has not differed appreciably from that now, which could hold true if the inner core was already before CE in the expanded state as also water containing regions, the idea about dark photons from the inner core as a metabolic energy source, which would make possible the evolution of photosynthesis in underground oceans, makes sense.

3. A model for the growth of the Earth radius by factor 2

The idea about relatively fast growth of the Earth radius by factor 2 raises the eyebrows of standard physicists. How can such a large change of density make sense? It seems safe to exclude the possibility that the mass of Earth has increased roughly by a factor of 8 (mass should have arrived from dark magnetic flux tube structure to which the core of Earth is associated as a tangle).

Monopole flux tube spaghetti should determine the structure of the ordinary condensed matter making Earth. One can consider several possibilities by allowing a fractal behaviour of the matter density induced by the structure of the flux tube spaghetti if it does not fill the entire volume [L120, L105].

The increase of the radius of Earth by factor about 2 means that the average density decreases by a factor 1/8. I have considered several options for what this could mean.

- (a) Quantum gravitation plays a key role in the TGD view of the emergence of life [L125] and brings in a completely new element. Density fluctuations at quantum criticality associated with the density changing phase transitions, such as freezing and evaporation, affect gravitational binding energy dramatically in long scales. This leads to a view how life could have evolved from this kind of quantum criticality. If the density fluctuations correspond to local scalings, they affect all gravitational binding energies in the same manner by reducing them.

Quantum gravitational Compton length $\Lambda_{gr} GM/\beta_0$ using the definition $\hbar_{gr} = GMm/\beta_0$ defines the key parameter. This suggests a considerable flexibility since the transition

could be induced from the level of quantum gravitational flux tubes and leave the details for what happens in scales below Λ_{gr} open.

- (b) Both the necessity of local scalings and energy conservation in the transition give further constraints. In the scaling of the radius of Earth by factor 2 induced by local scalings, the gravitational binding energy is reduced dramatically. There must be a way to compensate for the increase of the energy. Energy must be liberated in some degrees of freedom and condensed matter degrees of freedom in atomic scales are a natural candidate here.

For protons the gravitational binding energy is below .5 eV and for nucleus with mass number A it is below $.5A$ eV. The reduction of the gravitational binding energy per particle in the phase transition would be of this order of magnitude. Encouragingly, this energy corresponds to a typical energy scale for the interactions energies between atoms.

- (c) The electronic size of an atom is inversely proportional to $n^2 h_{eff}^2 / Z^2$, where n is the principal quantum number for valence electrons and Z is the charge of the atomic nucleus. The electronic binding energies are proportional to $Z^2 n^2 / h_{eff}^2$ so that the transition would require energy feed if scaling occurs in electronic degrees of freedom. Energy is not liberated. Furthermore, the electronic size of the atom cannot be affected in the transition.

Note however that the experiments of Randell Mills [D23] provide support for the possibility of h_{eff} smaller than h for valence electrons [L38]. The TGD inspired model for chemical bonds [L51] suggests that the value of h_{eff} characterizes valence bonds.

- (d) Second possibility is that the energy is liberated in atomic size scales defined in terms of the size lattice constant a defining the unit cell of the atomic lattice, which is rather constant. The atomic p-adic length scale defining a would increase by factor 2 or the value of h_{eff} assignable to the atomic p-adic length scale (the p-adic length scale $L(137)$ is a good guess) increases by a factor 2 from $h/2$ to h . Note that before the transition the value of h_{eff} assignable to a cannot be the same as the value assignable to the atomic electrons, since the latter cannot change in the transition.

The reduction of the gravitational binding energy should correspond to the liberated interatomic interaction energy depending on a which would increase by a factor 2. If this interaction energy can be regarded as positive interaction energy of positively charged atoms without conduction electrons, it is positive, and would decrease in the transition and could compensate for the reduction of the gravitational binding energy.

- (e) The phase transition would have been local and occurred gradually. The regions of water containing the photosynthesizing life forms and multicellular animals would have been in the recent phase already before CD. Water atoms behaved like dark matter since h_{eff} was twice its value for other atoms (as unit cells).

The same could apply also to the inner core serving as a source of dark photons providing the metabolic energy. Indeed, the radius of the inner core is roughly $1/5$ of the radius of Earth, so that the possibility that also the inner core was in the ordinary phase looks realistic: the doubling of the Earth radius would be replaced with a scaling by factor $10/6$.

Only the mantle would have been in the exotic phase. Of course, also the uppermost layers could have been also in the ordinary phase as the recent situation on Mars would suggest. The phase transition would have gradually proceeded in the mantle during the period when the radius of Earth was doubled.

- (f) The arguments of [L105] based on the idea that CP_2 length scale corresponds actually to Planck length scaled by factor $\sqrt{h/h_0}$ led to a speculation that $h_{eff} = h$ could be proportional to integer $n_0 = (7!)^2$ defining the order of Galois group for the number theoretic ground state in the length scales of atomic physics [L110]. $7!$ would correspond

to the order of the permutation group S_7 and $S_7 \times S_7$ would define the Galois group of the ground state corresponding to $\hbar_{eff} = \hbar$.

This suggests that the order of the Galois group was given by $n = n_0/2 = 7!^2/2$ before CE and was replaced with $n_0 = (7!)^2$ in CE. The Galois group would have been $S_7 \times A_7$, where A_7 is an alternating group, which is simple. Z_2 is the only normal subgroup of S_7 .

Can one imagine any evidence for an analog of the exotic phase in the framework of known physics? In the case of water, superionic ice [D25] (<https://cutt.ly/uXUIkUQ> and <https://cutt.ly/3XUIWhX>) existing at extreme pressures is a possible candidate for the exotic phase of water. Superionic ice is proposed to appear in the mantles of giant planets such as Uranus and Neptune and in [L120, L105] the possibility that it could occurring the Earth's mantle was considered. The density of superionic ice is slightly less than 4 times the density of ordinary ice. The reduction of \hbar_{eff} with factor 2 ($n = n_0/2 = (7!)^2/2$) would give a density, which is 8 times the density of ordinary ice. The increase of the density by factor 2 would require effective 2-dimensionality but superionic ice is 3-D.

4. Quantum gravitational metabolism

Consider first the quantum gravitational metabolism at Earth in the recent situation. In [L129], I discussed the following vision.

- (a) The long gravitational monopole flux tubes with $\hbar_{eff} = \hbar_{gr} = GM_E m / \beta_0$, $\beta_0 = v_0/c \leq 1$, have lengths much longer than gravitational Compton length $\Lambda_{gr} = \hbar_{gr}/m = GM/\beta_0$ does not depend on the mass m of charged particle, now proton at the dark hydrogen bond. Λ_{gr} is about .45 cm for $\beta \simeq 1$ using $\hbar_{gr} = GMm/\beta_0$. There are several pieces of evidence suggesting that Λ_{gr} is a fundamental scale of hydrodynamics [L115, L125].

The length of long dark hydrogen bond flux tubes should be of order Earth size scale. For the recent life forms they would extend from the surface of Earth to the atmosphere.

The dark photons of sunlight are absorbed by these flux tubes and this would increase the length if the energy reduces the gravitational binding energy. These flux tubes would serve as quantum gravitational batteries just like cell membranes as electromagnetic batteries.

- (b) Skeptics can of course wonder how it is possible that extremely weak gravitational interaction of gravitation and photons allows the transfer of dark photon energy to gravitational degrees of freedom. As a matter of fact, quantum coherence means that gravitational interaction is actually extremely strong!

In ordinary quantum theory one should use $\alpha_{gr} = GMm/\hbar$ as a coupling strength. It is larger than unity for Mm larger than Planck mass squared and the perturbation series fails! The introduction of \hbar_{gr} saves the perturbation theory! As a matter of fact, the original motivation for \hbar_{eff} was that the Universe is theoretician friendly and the increase of \hbar means a phase transition making perturbation theory possible.

One can characterize dark gravitational interaction by a dimensionless coupling parameter $\alpha_{gr} = GMm/4\pi\hbar_{gr} = \beta_0/4\pi$, which depends on β_0 only and is $1/4\pi$ for $\beta_0 = 1$ and therefore by a factor $1/e^2$ larger than fine structure constant and still of the same size as strong coupling strength α_s !

- (c) The upper bound for the gravitational binding energy of a proton in the Earth's gravitational field is of the order of . 5 eV metabolic energy quantum. If the dark proton at the long flux tube is localized at the surface of Earth, its gravitational binding energy increases and energy is liberated as metabolic energy. The flux tube can be given the original length by the absorption of a dark photon of solar radiation. The order of magnitude of energy is around metabolic energy quantum if 3 protons are localized simultaneously [L129]. ATP machinery indeed involves 3 protons which could have formed dark 3-proton.

- (d) The model also predicts a new metabolic energy currency associated with electrons. It is by the ratio $m_e/m_p \simeq 2^{-11}$ smaller than the standard metabolic energy quantum with the nominal value .5 eV.

5. The situation before CE

Consider now the situation before CE, when oceans were underground. One can imagine several options depending on whether dark solar radiation, dark photons from the Earth's core, or both provide the metabolic energy in the primordial photosynthesis.

- (a) For the simplest option involving only dark photons from the Earth's core, the dark flux gravitational flux tubes extending downwards to the interior of Earth would be spontaneously formed and their formation would have liberated metabolic energy given by the increase of the gravitational potential. If the flux tube extends down to the surface of the inner core with radius of $2R_E/5$, the metabolic energy released for the hydrogen bond would be about 1.5 eV to be compared with metabolic energy quantum of .5 eV. The absorption of a dark photon with energy of 2 eV would leave .5 eV of metabolic energy.

One can ask whether the ADP molecule could have contained this kind of long dark hydrogen bond and whether it could have shortened in $\text{ADP} \rightarrow \text{ATP}$ transition by absorption of a dark photon before CE.

One can also imagine that the dark cyclotron state of the dark proton was excited by the dark solar photon and was liberated as the metabolic energy in the interior as the dark proton was localized.

- (b) Could the dark photons from the Earth's core be involved with the metabolism of recent life forms? Say those living underground? Could the increase of the radius of Earth by a factor of 2 have reduced the rate for the increase of the length of dark hydrogen bonds so that this mechanism became insignificant? Could one imagine that the Earth's mantle still contains life forms utilizing the core of Earth as a metabolic energy source? I have suggested this half-jokingly for more than 2 decades ago [K41, K40].

The next question concerns the identification of the primordial photosynthesizers.

- (a) They would have been the underground counterparts of the recent plants. Dark magnetic flux tubes emanating from them would have formed a kind of magnetic forest.
- (b) They did not have roots, leaves, nor flowers and lived in underground oceans and did photosynthesis. Algae <https://cutt.ly/9XTBTE0> living in oceans satisfy these conditions. They include cyanobacteria (red and green algae) and glaucophytes. They or their predecessors (at least cyanobacteria) should have lived in the underground oceans and have evolved to the recent algae and plants after CE. Interestingly, algae produce most of the oxygen of Earth also in the recent biosphere. Cyanobacteria living in endosymbiosis with algae are the first known organisms that have produced oxygen.
- (c) This picture also solves the problem of how the oceans were oxygenated. They were oxygenated from the beginning and only bursted to the surface of Earth in CE.
- (d) This picture also conforms with the proposal of Lane that Earth and cell are very much analogous and makes this idea very concrete. The TGD variant of this proposal suggests that lightnings are actually analogs of action potentials possible even for unicellular organisms.

14.6.3 Appendix: A Corrected physical interpretation of the parameter β_0

Writing of this article led to an observation an apparent paradox, which resulted from a wrong interpretation of the parameter β_0 in Nottale's formula.

- (a) As already discussed, the quantum gravitational phase transition reducing the value of β_0 by factor 2 was involved with CE and led to the increase of the radius of Earth by factor 2.

There are indications that the recent value β_0 is $\beta_0 \simeq 1$ and thus near to the maximal value [L115, L125]. This however leads to the conclusion that $\beta_0 = 2$ was true before CE. This leads to a contradiction if one assumes that $\beta_0 = v_0/c$ is consistent with special relativity.

- (b) The resolution of the apparent contradiction is based on the fact that the definition of the parameter β_0 in the Nottale's formula is actually not unique and determined only by scaling without further inputs such as the condition $\beta_0 \leq 1$. Therefore one can replace the formula $\hbar_{gr} = GMm/\beta$ with the formula $\hbar_{gr} = GMm/2\beta_{0,ph}$ if one defines $\beta_{0,ph} = \beta_0/2$. For this option, the value of $\beta_{0,ph}$ would have decreased from $\beta_{0,ph} = 1$ to $\beta_{0,ph} = 1/2$ in CE. The value of Λ_{gr} after CE would be $\Lambda_{gr} = GM/2\beta_{0,ph} = r_s/2$ just as proposed earlier [L115, L125].

14.7 About the mechanism of the energy transfer in photosynthesis

I learned about very interesting results related to photosynthesis. A popular article on the BigThink page (<https://rb.gy/phb4c>) tells about an article published in the journal PNAS [?] (rb.gy/9zppa).

The basic mystery of photosynthesis is extreme energy efficiency. Up to 95% of the photon's energy is transmitted in a medium that would seem to be as inhospitable as possible for energy transmission with almost no dissipation. The use of very low temperatures, the shooting of monochromatic photons into a lattice, and superconductivity are out of the question. The incoming photons also have a wavelength distribution, which does not facilitate the energy transfer either.

14.7.1 Some facts

Consider first a summary of the basic findings and conclusions.

- (a) Chlorophyll is the basic structure involved with photosynthesis. Its basic function is to gather solar energy and transfer it to the reaction center where the energy is stored to various biomolecules. There are 2 wavelength bands, corresponding to 430 nm in blue and 662 nm in red, where the absorption is especially strong. The so-called LH2 proteins act as antennas absorbing photons. In the reaction center LH1 proteins perform photosynthesis by building biomolecules to which the solar energy is stored.
- (b) It has been observed that the lower limit of the size of the so-called light-absorbing LH2 antenna proteins is 2.5 nm. It is also the minimum distance between LH2 proteins. The proposal is that the LH2 antenna network could somehow make the transfer of energy almost without dissipation.

It is believed that the disorganization of the proteins might explain this. However, in the popular article there was no intuitive argument as to why this is so. The claim is made on the basis of computational models and empirical facts gained by studying the transfer process. I find it difficult to imagine how the irregular positions of proteins could promote the process.

- (c) The proposed interpretation of the findings is as follows. A photon enters and excites the electron of the LH2 protein. When the electron is de-excited, one or more photons are generated which in turn excite the electrons of the next LH2 proteins. Finally, the generated photons excite the electrons of the reaction center and these electrons are used in the photosynthetic process to produce sugar molecules.

14.7.2 The TGD based model

The findings seem to resonate with two key views of the TGD inspired quantum biology.

- (a) Photosynthesis involves at least a temporary storage of solar energy to quantum gravitational energy batteries [L129, L125].
- (b) There is dark variant of the genetic code and realization of dark DNA double strand base on the icosahedral tessellation [L144] of the hyperbolic 3-space H^3 , which is realized both as a mass shell in $M^4 \subset M^8$ and light-cone proper time=constant 3-surface in $M^4 \subset M^4 \times CP_2$.

Icosa-tetrahedral and possible other hyperbolic tessellations would be associated, not with the biological body, but with the magnetic body (MB) of the biosystem carrying dark matter identified as phases of the ordinary matter with effective Planck constant $\hbar_{eff} = n\hbar_0$. The location of dark matter at the field body would explain why dark matter has not been found in various searches.

Basic questions

What are the questions waiting for an answer?

- (a) Why would the dissipation be so low? Quantum coherence in a scale of at least the order of tens of nanometers could guarantee this. Dark matter as phases with a large value of \hbar_{eff} indeed implies a long quantum coherence scale. Also a regular crystal structure is a natural prerequisite for a low dissipation. The dissipation is minimized if the energy, or possibly the electrons, are transferred through the hyperbolic tessellation of the MB carrying dark matter.
- (b) The minimum distance between LH2 proteins is about 2.5-4 nanometers, which corresponds to the DNA codon size scale. In the TGD based model for genetic code, the dark realization of the genetic code and the DNA double helix are connected to an icosatetrahedral honeycomb in hyperbolic 3-space H^3 assigned with the MB [L144]. Could the crystalline structure be realized by using the same icosatetrahedral tessellation as associated with the dark DNA and dark genome controlling the ordinary genome.

If the transfer of energy to the reaction center occur at the MB as a transfer of dark electrons, the dissipation could be very small since there would be no direct interaction of the dark electrons with the ordinary matter if the interaction vertices can involve only particles with the same value of \hbar_{eff} , as seems natural.

Quantitative data

Consider next the quantitative data.

- (a) The distance between LH2 proteins is in the range 2.5-3.1 nm. This scale corresponds to the DNA codon size scale and to the cell size of the fundamental region of the icosatetrahedral tessellation, which has Platonic solids as cells [L144]. There are 12 icosahedrons, 20 tetrahedrons and 30 octahedrons forming a region of size 10 nm, which corresponds to the p-adic length scale $L(151)$ (associated with a p-adic prime $p \simeq 2^k$, $k = 151$) appearing as a characteristic length scale in biomatter. This region corresponds to 10 DNA codons for which the total twist along the DNA strand is 6π that is 3 full turns.

- (b) The size of the structure involved with the photosynthesis would be naturally cell size scale? The wavelength of the red light gives a length scale of order $.5 \mu\text{m}$ and serves a natural lower bound. Note that cell nucleus size is about $1 \mu\text{m}$.
- (c) The time τ required for the energy transfer between adjacent antenna proteins varies from 5.7 to 14 ps. In time τ , the distance traveled by the light is $L = 1.71 - 4.2 \text{ mm}$. Interestingly, for Earth the gravitational Compton wavelength $\Lambda_{gr}(E) = GM_E/\beta_0(E)$ is for $\beta_0(E) = v_0/c = 1$ equal to $\Lambda_{gr}(E) = 4.5 \text{ mm}$. Gravitational Compton frequency is $f_{gr}(E) = 67 \text{ GHz}$ and corresponds to a time of about $T_{gr}(E) = 15 \text{ ps}$, the upper limit for the estimated time.

f_{gr} corresponds to a photon energy of $E_{gr} = .27 \text{ meV}$. The electronic metabolic energy quantum in the case of the Earth would be related by a factor m_e/m_p the protonic metabolic energy quantum identifiable as standard metabolic energy currency. The model for the findings of Andrew Adamatsky [I52] suggests that sponges have a language based on membrane potential oscillations with membrane potential variations of order mV. The TGD based model suggests the existence of metabolic energy quantum of this order of magnitude [L129]! meV is also the energy associated with the miniature membrane potentials. Could τ be identifiable as the gravitational Compton time T_{gr} at which the dark matter at the MB would oscillate?

How could the electrons be transferred to the reaction center as dark electrons?

Could the process at the level of LH2 antenna proteins correspond to the propagation of the dark electron and the hole associated with it? The dark electron would hop between the sites of the tessellation perhaps by quantum tunneling, which in TGD Universe corresponds to a pair of "big" (ordinary) state function reductions (BSFRs) changing the arrow of time temporarily. The dark electron current would be analogous to super current and the system "hole + dark electron" would be analogous to a Cooper pair.

- (a) The duration τ of a single step should correspond to the oscillation period $\tau \sim T_{gr}$. If so, the oscillation would play the role of EEG resonance oscillation coordinating the transfer by induces the pairs of BSFRs.
- (b) The first guess is that electrons are converted to dark electrons with a large value of the gravitational Planck's constant $\hbar_{eff} = \hbar_{gr} = GMm/\beta_0(M)$ [E2] located at the gravitational MB of the Earth or Sun. They would be transferred to the U-shaped monopole flux tubes and the reduction of the binding energy of the electron would be equal to the energy of the incoming photon absorbed by it.

The reduction of the binding energy cannot be however purely gravitational. For electrons, the maximal gravitational binding energy in the case of the Earth is about $E_{gr}(Earth, e) = .25 \text{ meV}$ whereas the incoming photon has energy $E \simeq x \times .5 \text{ eV}$, where x is in the range 4 to 6 in the wavelength range considered. For the Sun the maximal binding energy E_{gr} is reduced by the ratio $[M(Earth)/M(Sun)] \times [R(Sun)/R(Earth)] = .071$. In the case of protons with $E_{gr}(Earth, p) = .5 \text{ eV}$ this gives to $E_{gr}(Sun, p) = .14 \text{ eV}$, which happens to be roughly twice the energy assignable to membrane potential. For electrons this gives $E_{gr}(Sun, e) = 1.8 \mu\text{eV}$.

For the energy transfer in photosynthesis, the energy of the solar photon cannot therefore correspond to the change of gravitational binding energy in the case of electrons. Rather, the energy must be identified as the change of electromagnetic binding energy as an atom is effectively ionized when an electron becomes a dark electron at the MB. This MB need not be gravitational and could also correspond to a relatively small $\hbar_{eff} > \hbar$.

- (c) What comes to mind are dark unpaired valence electron states of atoms in which the \hbar_{eff} of an unpaired electron increases so that binding energy is scaled down by $1/\hbar_{eff}^2$. The binding energy spectrum of the dark electron states is obtained by scaling the

ordinary binding energy spectrum and these states are analogous Rydberg states in that the radius of Bohr orbits is scaled up by h_{eff}^2 . If the valence electron becomes gravitationally dark ($h_{eff} = h_{gr}$), the atom effectively suffers ionization to a state with vanishing energy and positive charge. Dark ions could correspond to this kind of states.

- (d) How could the energy transfer to the reaction center take place? The simplest mechanism could be the following. One can charge the solar energy batteries by transforming ordinary electrons to dark electrons at the MB of the Sun. At the reaction center the dark electrons drop back and transform to ordinary electrons and are available for the photosynthesis proper, storing the energy to biomolecules.

The experimental findings could be consistent with the assumption that the pairs formed by a dark electron and hole move to the reaction center, and the movement of the dark electron is analogous to a conduction in a lattice by hopping. The lattice could correspond to the tetra-icosahedral tessellation assignable also with DNA and genetic code. The time for one transition would correspond to $T_{gr}(Earth) \sim 15ns$. This supports the view that the MB of the Earth is present.

- (e) Why would the dropping down to Earth take place in the reaction center? The holes have an effective positive charge because the dark electrons have a large distance to the surface of Earth. If the reaction center has a negative charge, it attracts the positively charged holes. The holes move towards the reaction center and the dark electrons and gravitational monopole flux tubes and dark electrons follow. The electrons transform to normal ones and holes disappear. The predicted negative charge of the reaction center serves as a test for the proposal.
- (f) How this negatively charged region in the reaction center could be generated? Pollack effect [I126, L25, ?, ?], discussed from the TGD point of view in [L25], is caused by (say) IR radiation in the presence of gel phase, and indeed generates negatively charged exclusion zones. The exclusion zones could be due the transfer of protons of water molecules to dark protons at the flux tubes of the MB, which is however not gravitational. Both cells and DNA represent examples of negatively charged objects. Pollack effect is indeed a key element of the TGD inspired view of living matter. There it is natural to assume that the exclusion zone is present also in the reaction center.

If the energies of dark electrons and holes are separately conserved, they can annihilate to the ordinary electron in the reaction center. Can this be true?

- (a) Why would the energy of the dark electron be conserved in the hopping along the tessellation? Single step would correspond to a motion under the magnetic Lorentz force, which conserves energy since force is orthogonal to the velocity.
- (b) What about the dark electron-hole interaction? This interaction is present if the flux tube follows the motion of the hole-dark electron pair. This pair would form a bound state analogous to the Cooper pair and its energy would be conserved if its scattering would reduce to the magnetic scattering of the dark electron. The situation would be very much like in the case of superconductivity.
- (c) If the hole corresponds to a transition of an unpaired valence electron to a large h_{eff} analog of a Rydberg state with a very large size, the binding energy and energy of the state is very near to zero. The ionization energy scale for valence electrons is measured in electron volts just like for the photons from the Sun.

The energy scale for icosi-tetrahedral honeycomb scaling like $\hbar_{eff}^2/(2m_e L^2)$, L the size of the fundamental region, gives an estimate for the unit of energy quantization, which does not depend on \hbar_{eff} . The energy scale is 10^2 eV for $L = L(151) = 10$ nm. This scale is expected to be very large as compared to the energy gap so that transitions are not possible. The situation would be like in superconductivity and superfluidity.

- (d) What about energy conservation in the motion of the localized valence hole? Valence electron hole can be replaced with the valence electron of a neighboring atom and this makes possible its movement towards the negatively charged reaction center. The energy of the valence hole in the center of mass system of the atom is not changed but the ionized atom or the molecule containing it would experience the Coulomb force assumed to be associated with the reaction center and its center of mass energy can change.

How is it possible that the attractive Coulomb field between the hole and the reaction center does not affect the energy of the valence hole? The question is well-motivated. The Coulomb energy between the hole and the reaction center is expected to be much larger than the energy gap. For instance, for distance of $1 \mu\text{m}$ the Coulomb energy between unit charges is of order 10^{-2} eV.

What prevents the valence hole from accelerating and getting more energetic? The U-shaped gravitational magnetic flux tube has a string tension and the lengthening of the flux tube could compensate for the Coulomb force. The Coulomb energy would be transformed to elastic energy of the flux tube. In the reaction center the flux tube would contract and the dark electron could fuse with the hole having the same energy.

Is this picture consistent with the quantum gravitational storage of metabolic energy?

Is this picture consistent with the earlier proposal for the metabolic energy storage, which is based on the notion of gravitationally dark protons [L129] and also predicts electronic metabolic energy currency of about .25 meV for which there is some evidence [I52]?

- (a) The motivation for the proposal is that the gravitational potential energy of a proton at the surface of Earth is .5 eV: this happens to be the nominal value of metabolic energy quantum. Of course, since the electromagnetic binding energies in molecular scale are measured using eV as units, this might be a pure accident. The weaker optimistic interpretation is that this coincidence makes possible interaction between quantum gravitational and quantum electromagnetic degrees of freedom.

When the distance from the surface of Earth in the direction of the Sun, the gravitational forces of Sun and Earth are identical. This condition gives an upper bound for the distance $r(\text{Earth})$ of the particle from the Earth in the direction of Sun as $r(\text{Earth})/AU - r(\text{Earth}) = \sqrt{M(\text{Earth})/M(\text{Sun})}$ giving $r(\text{Earth}) \simeq 100R(\text{Earth})$ to be compared to the distance of Moon about $r(\text{Moon}) \simeq 60R(\text{Earth})$. The value of the gravitational potential difference as is 99% of the maximal one.

The proposal [L129] is that the transformation of protons of water molecules to gravitationally dark protons could serve as a mechanism for the storage of metabolic energy.

If the metabolic energy quantum is determined *solely* by the gravitation of Earth, this mechanism does not work at large distances from the surface of Earth. The fact that Moon travellers have survived does not favor a purely gravitational mechanism but the fact that molecular binding energies are of the same order, might save the mechanism. A more imaginative option is that the gravitational MB of the Moon traveller is still associated with Earth and makes it possible to store metabolic energy to the gravitational MB of Earth.

- (b) Dark protons triplets could serve as a storage of metabolic energy in the case of ATP (high energy phosphate bond) and maybe even in the case of biomolecules. This is supported by the appearance of 3 protons as a kind of basic unit in $\text{ATP} \rightarrow \text{ADP}$ metabolic machinery.
- (c) In the Pollack effect, IR radiation effectively ionizes water molecules and produces effective stoichiometry $\text{H}_{1.5}\text{O}$ inside a negatively charged exclusion zone. The decrease of the electronic binding energy per water molecule in the Pollack effect could be naturally

given by the energy of the IR photon and would be rather small. If the Coulomb binding energy of the dark proton triplets with the exclusion zone is equal the metabolic energy quantum $E = .5$ eV, the reduction of the gravitational binding energy in the transfer of dark proton triplet to the gravitational MB would be given by E and would lead to a zero energy state. Could one the build-up the energy carrying bio-molecules by transferring dark proton triplet to the gravitational magnetic bodies of the biomolecules by using the energy liberated by dark electrons as they drop down and transform to ordinary electrons in the reaction center?

14.8 Appendix: Basic facts about cilia and flagella

Intermediate filaments, actins and microtubules (MTs) are basic structures of cytoskeleton. MTs are associated with centrosome, cell membrane protrusions known as cilia, flagella, and axons (<https://cutt.ly/FDnfEVP>). Axonal MTs and part of MTs in the cell interior are dynamical and have a varying length. Actins are protrusions of the plasma membrane protrusions known as microvilli (<https://cutt.ly/HDRaxxf>) are analogous to cilia.

Cilia, flagella, axons, and microvilli are involved with motor activities of some kind. In the case of MTs and actins, contractions and lengthenings define the basic element of dynamics. Actin dynamics relates to the gross motion of the cell. The dynamics of axonal MTs might also relate to the nerve pulse conduction. Axonal MTs are not organized into regular structures like the other MTs.

Motile cilia and flagella are predecessors of muscles and motor system. Primary cilia function as antennas and act as mechanical, chemical, and thermal sensory organs.

14.8.1 Structure and function of cilia

Cilia start from the basal body. One can distinguish between primary and motile cilia (<https://cutt.ly/IDnfKAB>). Unlike motile cilia, primary cilia do not beat and dynein arms and other structures needed for motion are missing. These cilia act as antennas and sensory receptors. All sensory cells have cilia playing the same role so that cilia could be seen as cellular sensory and motor organs.

- (a) Cilium is a cylindrical protuberance of the plasma membrane. Its radius is about $.1 \mu\text{m}$ to be compared with axonal radius about $.25 \mu\text{m}$. The length of cilium varies in the range $1\text{--}30 \mu\text{m}$.
- (b) Inside cilium is its cytoskeleton known as axoneme. For motile cilia the MTs of the axoneme have $9+2$ structure and for primary cilia they have $9+0$ structure. For the basal bodies the structure consists of a ring of 9 MT triplets without central MTs. Vertebrates can also have other types of cilia.
- (c) The 9 pairs of the ring are partially overlapping, which makes it possible for them to glide with respect to each other: this induces the bending of the motile cilium. The tubulins of these pairs are horizontally connected by nexin bonds to form a ring-like structure. Radial spokes and outer and inner dynein arms force the gliding motion. The pairs or rings consist of two kinds of MTs. The MT of type A has 13 tubulin protofilaments and MT of type B has 10 protofilaments. In motile cilia and flagella, structures essential for motility, such as axonemal dyneins, radial spokes, and the nexin dynein regulatory complex (N-DRC), are arranged on DMTs with a 96-nm repeating unit.
- (d) The members of the central pair are non-overlapping MTs connected by a bridge. The center MTs are involved with the control of the ciliary motion induced by the gliding. Stabilization of cilia MTs is by inner lumen proteins. The structure and protein composition of motile cilia and flagella are well conserved among eukaryotes.

14.8.2 Beating waves

Cilia and flagella have similar structures and only their functions differ. Cilia force liquid to move with respect to the cell. Flagella make it possible for the cell to move with respect to liquid (<https://cutt.ly/TDngqh0>). The force needed for cilia beating is produced by the outer and inner dynein arms of the axonemal microtubule doublets connected to the central pair of microtubules by radial spokes. Airway cilia have components typical for motile cilia.

- (a) Motile cilia and flagella beat in a synchronized pattern. This coordination is achieved by metachronal rhythm, in which a wave of simultaneously beating groups of cilia moves from the anterior to the posterior end of the organism. The motions of cilia along the cell surface have different phases so that the motion looks like a wave: mexican wave (<https://cutt.ly/iDRUehV>) is a good example of this. The waves in the crop field induced by wind serve as a good example.

- (b) The cilia on the same line perpendicular to the direction of the effective stroke are synchronized and thus have the same phase, and adjacent rows of cilia parallel to the direction of the effective stroke beat with a phase difference.

Beating corresponds to a contraction wave and here the dynein arms are in an essential role. Orientation, beating frequency, wavelength, amplitude parametrize the motion of cilium.

- (c) Waves begin from cilia rather than the basal body so that the obvious idea that the cell would initiate the motion, need not be correct. Various wave forms such as plane waves and non-symmetric waves cause the bending.
- (d) The beating frequency varies in EEG range, which need not be an accident. Some sources report beating frequencies in the range 4-10 Hz. Some sources report 20-60 Hz frequency (<https://cutt.ly/uDngfy0>).

Chapter 15

Comparison of Orch-OR hypothesis with the TGD point of view

15.1 Introduction

Diosi-Penrose variant of the Orch-Or [J61] model constrains the range of the separation parameter R , also called the resolution scale of matter density, and predicts that weak em radiation accompanies Orc-OR, which are not predicted by the original Penrose model [J112]. Two years ago experiments by Donadi et al carried out in Gran Sasso underground laboratory failed to detect the predicted radiation [D17] (see <https://cutt.ly/JJ569SI> or arXiv version <https://cutt.ly/ZJ56482>).

These conclusions have been strengthened in a theoretical article by Diosi et al [J52] (<https://cutt.ly/8J6qdD8>) inspired by these experimental findings. The authors represented theoretical arguments leading to the conclusion that D-P theory theory is highly implausible with reasonable values of the scale parameter R .

According to the abstract of [J52], partial separation, applying at the microtubular (MT) level, requires the brain to maintain coherent superpositions of tubulin of such mass, duration, and size that vastly exceed any of the coherent superposition states that have been achieved with state-of-the-art optomechanics and macromolecular interference experiments. The conclusion is that none of the scenarios discussed in the article (with a possible exception to the case of partial separation of tubulins) are plausible. There is also a popular article (<https://cutt.ly/KJ6qrPp>) briefly summarizing these conclusions.

In the sequel Penrose view about gravitational state function collapse, Penrose-Hameroff (P-H) model (P-H model) and Diosi-Penrose (D-P) model are discussed from the TGD point of view.

15.1.1 Penrose theory

It is appropriate to briefly summarize the assumptions of the original Penrose theory [J112] for quantum gravitationally induced state function collapse.

- (a) Quantum superpositions for masses in different configurations have different gravitational energies. Also gravitational fields must appear in quantum superposition. However, since a theory of quantum gravitation is lacking, it is not clear how to mathematically formulate this intuition.

The description of the two states with different self-interaction energies relies on a classical non-relativistic description of gravitation. When two configurations in the

superposition are known, it is in principle straightforward to calculate the difference E_g of self-interaction energies.

The basic hypothesis is that the superpositions of gravitational fields of different configurations are unstable against collapse. For simplicity a superposition of two configurations is assumed.

- (b) An intuitive estimate for the duration of the state ending with collapse is based on Uncertainty Principle:

$$\tau \sim \frac{\hbar}{E_g}.$$

τ inversely proportional to E_g . τ is suggested to correspond to a typical time scale of human consciousness via the formula $\tau = \hbar/E_g$. The value of E_g is extremely small, which makes gravitational quantum coherence extremely vulnerable.

- (c) One must somehow characterize the states appearing in the superposition. The notion of separation distance R characterizes ΔE_g . The value of R must be guessed. This is not easy since the very definition of R remains unclear, at least to me. One could take R only as a phenomenological parameter characterizing the resolution scale.

Alternative identification would be as a separation distance. Separation would mean creation of a superposition of two classical configurations for which internal gravitational energies differ. As if the distance between nucleons of nuclei or between nuclei of atoms had changed by length R . For nuclei (atoms) R would correspond to the nucleon (nuclear) size scale.

Coherence is required in the sense that the change of gravitational energies tends to be of the same sign for all particles. Otherwise the change E_g of the gravitational self-interaction energy is expected to be vanishingly small to give short enough $\tau \simeq \hbar/E_g$.

- (d) Since the change of gravitational interaction energy for all particle pairs must be of the same sign, the replacement of R as a scaling parameter comes into mind: different configurations would differ by a scaling.

15.1.2 Penrose-Hameroff theory of consciousness

Penrose's view about gravitational state function reduction [J112] is part of the Orch-OR proposal of Penrose and Hameroff [J79, J74, J78]. The duration of the quantum gravitational coherence must last long enough, of the order of the typical time scale of conscious experience or possibly time between two conscious experiences. Perturbations should not induce a too fast decoherence: in standard quantum theory this looks unavoidable.

- (a) Microtubule (MT) hypothesis states that MTs are systems able to appear in quantum gravitational superpositions. Why this should be the case, remains unclear to me.
- (b) Superpositions of MT configurations must last long enough. τ could correspond either to the duration of conscious experience or time between two moments of consciousness. τ should be long enough and is estimated to be in the range 5 sec- 10^{-2} seconds. $\tau = \hbar/E_g$ gives an estimate for E_g , which is extremely small, of order 10^{-13} eV for $\tau = .1$ seconds corresponding to 10 Hz frequency in alpha band. Extremely small energies (in comparison to metabolic energy quantum of about .5 eV) are involved and one can argue that electromagnetic interactions unavoidably spoil the gravitational quantum coherence in standard quantum physics framework.
- (c) The separation scale R appearing as a basic parameter must be estimated or rather, guessed. The problem is that the definition of R does not have clear geometric meaning. Atomic separation of order nuclear or nucleon size scale for Carbon atoms is assumed as a working hypothesis. The rate for a collapse in the case of a single Carbon atom can

be estimated from the dimensional estimate for the change of the gravitational energy as $E_g \simeq Gm^2/R$. The change is assumed to have the same sign for all Carbon atoms so that this estimate is multiplied by the number of Carbon atoms. $\tau = 25$ ms is assumed from a 40 Hz synchrony time scale. The gravitational quantum coherence of $N \sim 10^{11}$ tubulins is required with this assumption.

Tubulin has a mass of 50 kDa, and Da corresponds to proton mass. This makes a mass of $5 \times 10^{16} m_p = 3.9 \times 10^{-4}$ Planck masses. The length of a structure containing 10^{11} tubulins forming a cylinder of parallel 13 MTs, each consisting of 13 tubulin units of length about 10 nm, would be of order 15 m so that a single axon cannot satisfy the constraints. Empirical inputs restrict the value of R . Shifts of the nuclei would be measured in femtometers: $R = 2.5 fm$. 1 nm scale separations for electrons would be required.

The following items summarize what I found difficult to understand.

- (a) The changes of gravitational interaction energies should have the same sign in order to guarantee that τ is not too large. Scalings would satisfy this constraint. The notion of separation scale does not code for this intuition.
- (b) What about the changes of electromagnetic energies induced by the separation? Can they be the same for the states of superposition so that only gravitational energy would be liberated in Orch-OR?
- (c) Why would microtubules be so special? Why not for instance axonal membranes or DNA?
- (d) The idea that consciousness consists of moments identifiable as quantum jumps is attractive but in conflict with the idea that conscious experience has a duration. This has been a decades-long headache also in the TGD framework. Could the quantum jump be the beginning of a conscious experience and the next quantum jump the end of it? Could one have a kind of holography of consciousness with quantum jump as analog of the 3-D boundary of space-time coding the information determining the contents of conscious experience: this is the most recent TGD view [L137]. Also self hierarchy as analog of various geometric hierarchies of TGD would conform with the idea that the structures for the physical world and conscious experience reflect each other. A category theorist might speak of a functor between physics and consciousness.

15.1.3 Diosi-Penrose theory

Diosi-Penrose (D-P) theory involves the additional prediction that Orch-OR involves also weak emission of electromagnetic radiation. This emission is argued to take care of energy conservation, which both Penrose and Diosi, regard as an unphysical feature.

It must be emphasized, the loss of classical conservation laws defines the basic problem of general relativity since the isometries of Minkowski space-time are lost and Noether's theorem cannot be used to derive the existence of energy, momentum and angular momentum. It was just this problem, which led to TGD.

I must confess that I really do not understand the mechanism of energy liberation proposed by Diosi. The following is only my humble attempt to understand.

- (a) One would have a superposition of two states with different gravitational self-interaction energies. In a non-relativistic Newtonian mechanics, one can in principle assign well-defined energies to them. Also changes of electromagnetic interaction energies and kinetic energies of particles must be taken into account. The changes of both gravitational and electromagnetic interaction energies and changes of particle energies can be computed classically if the two configurations are specified precisely.

This is because the separation scale R , whatever it might mean, does not induce only a change of gravitational energy but also of electromagnetic interaction energies and kinetic energies. Stationarity assumption simplifies the situation.

In short scales, the changes of electromagnetic interaction energies have a completely different order of magnitude than gravitational interactional energies and this does not add to the plausibility of quantum gravitational coherence. In longer scales electromagnetic interaction energies are expected to compensate each other. Since gravitation is not screened, the situation can be and, in the case of MTs, should be different for gravitation.

A solution of the objections might be based on a precisely defined notion of scale hierarchy allowing to separate gravitational and electromagnetic interactions.

- (b) The predictions depend on the resolution scale R of mass density identified also as a separation distance R . R can correspond a) to tubulin protein scale (partial separation), b) atomic nuclei ($R \sim 2.5$ Fermi for Carbon atoms), or c) its nucleons. By estimates, R should be of order nuclear size scale or even of nucleon size (b) and c)).

The interpretation of the R has remained unclear for me. The illustrations of popular talks suggest an interpretation as a distance between copies of the system at different positions self-interaction energies for two configurations differing by a shift are the same.

If the shift occurs in the relative radial coordinates for the parts of the system and if one stays in the framework of general relativity, it is difficult to avoid the interpretation as scaling. Both local and global scalings could be considered. It however turns out that TGD allows a more elegant view [L129].

- (c) What about the total energies of the superposed configurations? If the state with a higher energy is less probable, the collapse tends to lead to a less energetic state and the collapse liberates energy.

The amount E_g of liberated gravitational binding energy liberated would be extremely small for $\tau = \hbar/E_g \sim .5 - 10^2$ sec, which corresponds to energy $E_g \simeq 10^{-12}$ eV. Here $E_g = N \times e$ refers to the total liberated energy. The total liberated energy would be proportional to the number of basic units in quantum coherence. For $R = \hbar/m_p$ and proton as a basic unit, this would give $e = Gm_p^3 \sim 10^{-38}m_p$. Roughly $N = 10^9$ protons would be required.

It would seem that in the Diosi-Penrose model the liberated energy must be essentially electromagnetic and kinetic energy. It is difficult to make any estimates without a detailed model. In any case, the electromagnetic energy would dominate at least in short enough scales.

- (d) The collapse is assumed to be a Poisson process: this reduces its description to a single particle level corresponding in scale R . Momentum changes should be random so that only dissipation visible as an increase of temperature should result. Temperature change is the measured observable.
- (e) Despite the incoherence for em interactions, the changes of gravitational self-interaction energies at single particle level should add up coherently. It is not easy to understand how gravitational coherence in long scales is possible if everything reduces to a single particle level and electromagnetic energy dominates. The existence of length scale hierarchy suggests a possible solution to this problem. The separation of electromagnetic and gravitational degrees of freedom however requires new physics.

To sum up, if the superposed states differ by scaling instead of R , the changes of both gravitational and em interaction energies could be estimated in the general relativistic framework from their scaling behavior and one obtains simple expressions. The estimate for the changes of kinetic energies requires some assumptions.

In the TGD framework scaling hypothesis is not necessary and for the already proposed mechanism of metabolism [L129] the space-time surfaces in the superposition do not differ by a scaling. However, it turns out that scaling induced density fluctuations could play an important role also in the TGD based view about quantum gravitation.

15.1.4 Empirical test of Diosi-Penrose theory

D-P model has been empirically tested by Donade et al [D17] (<https://cutt.ly/qKszmNC>). Authors estimate the rate for the emission of radiation predicted by the D-P model, which is faint but detectable. Also a dedicated experiment at the Gran Sasso underground laboratory to measure the emission rate is reported. The null result sets a lower bound on the effective size of the mass density of nuclei, which is about three orders of magnitude larger than previous bounds. This rules out the natural parameter-free version of the Diosi-Penrose model.

- (a) The weak radiation would relate to the change of electromagnetic energy induced by the change of gravitational self-interaction energy of charged particles. The radiation is assumed to be a single particle phenomenon occurring spontaneously as a Poisson process in short scales even without the quantum coherent superposition of gravitational fields. Therefore it is argued that a gravitational long length scale quantum coherence need not be present and non-biological systems can be used in the test. As explained, this hypothesis remains rather unclear to me since no detailed mechanism is proposed: only the existence of the radiation is proposed.

One must consider a system exhibiting quantum coherence in a long enough scale. This quantum coherence is assigned with conduction electrons. A shielded germanium detector is used.

- (b) The mathematical treatment, discussed in the Appendix of [D17], is based on the evolution equation for the density matrix containing operator terms representing matter Hamiltonian and gravitational self-interactions. The collapses at single particle level give rise to diffusion as charged particles liberate energy in gravitational collapse.
- (c) No emission was detected within the wavelength range corresponding to nuclear-atomic length scale range and therefore photon energies in the range $10 - 10^5$ eV. Note that the large energy scales suggested by Uncertainty Principle suggest that something is badly wrong with the model. If quantum gravitational coherence in biological scale is involved, this is not expected.

The separation scale R should be longer than atomic scale but this is excluded theoretically because the rate of spontaneous collapse would be quite too slow so that decoherence caused by other interactions would prevent long enough coherence time τ for Orch-OR.

In the sequel TGD based view of how quantum gravitation is present in quantum biology [L129, L134] is briefly summarized and compared with the ideas and models of Penrose, Hameroff and Diosi.

15.2 Comparison with TGD based approach

Quite recently, the role of quantum gravitation in the biology of the TGD Universe has been considerably clarified [L129, L134]. This includes quantum gravitational models of metabolism, biocatalysis, and the analog of topological quantum computation.

The TGD view about quantum gravitation differs in many aspects dramatically from that of Penrose. What is common is the vision about quantum coherent superpositions of space-times, now space-time surfaces, as also the proposal that MTs might have a special role as also water. The reason would be quantum criticality making possible long length scale

quantum fluctuations, which can be described in terms of the effective Planck constant \hbar_{eff} labelling phase of ordinary matter behaving like dark matter [K36, K37, K38, K39]. By its huge value, $\hbar_{eff} = \hbar_g r = GMm/v_0$, introduced originally by Nottale [E2], would be most important for biology and consciousness at brain level [K88, K14] [L118, L115].

For these reasons, it is interesting to find how the TGD view relates to P-H and D-P models.

15.2.1 TGD inspired quantum gravitational view about metabolism and nerve pulse conduction

A considerable progress in the understanding of quantum gravitational aspects of quantum biology in the TGD framework has taken place recently [L129, L134].

- (a) The TGD based view about cell and neuronal membrane, nerve pulse and EEG assumes pre-neural level, which is quantal. In this view, cell membranes act as Josephson junctions and communicate sensory input to the magnetic body (MB) of the system as dark Josephson radiation. MB in turn controls the cell by dark cyclotron radiation produced as pulses as MB receives frequency modulated Josephson radiation resonantly.

Number theoretic vision implies the notion of Galois confinement [L106], which inspires the notion of a dark N-particle, which consists of N dark particles as an analog of the color confined state of quarks. Dark 3N-protons and dark 3N-neutrons as fundamental representations of genetic code are central for the TGD inspired quantum biology [L96, L108]. Cyclotron 3N-resonance for dark 3N-protons makes possible targeted communications and control with gene defining the address of the receiver like in LISP and frequency scale modulation defining the signal transformed to N-cyclotron resonance peaks.

- (b) Gravitational MB of Earth, which consists of very long U-shaped tentacle like flux tube loops with a scale of the Earth radius with gravitational Planck constant \hbar_{gr} introduced by Nottale [E2] explains the findings of Blackman [J31] and others about physiological and behavioral effects of ELF radiation in EEG range, is of special interest and assumed to play a key role in metabolism. Gravitationally dark protons would be associated with very long gravitationally dark hydrogen bonds (HBs) so that hydrogen is effectively negatively ionized.

Gravitationally dark electrons or their Cooper pairs would in turn accompany gravitationally dark valence bonds connecting metal atoms or their Cooper pairs with molecules of opposite valence (hydrogen peroxide H_2O_2). Also the metal atom is effectively ionized. This provides a more accurate view of dark metal ions assumed to play a central role in the TGD inspired quantum biology.

- (c) The estimate for the upper bound metabolic energy quantum as the energy liberated as a dark proton HB becomes ordinary is of a correct order of magnitude. A more precise model predicts correctly the nominal value of metabolic energy quantum for proton triplets which appear also in the generation of ATP.

For triplets of electron Cooper pairs, the same mechanism predicts an upper bound of the electronic metabolic energy quantum, which corresponds to the so-called miniature potential of few meV. This raises the question whether the letters of genetic code could be realized by the 4 states of electron Cooper pairs and whether the Posner molecule could realize it [L129].

- (d) Electronic metabolism would solve the problem due the lack of ATP machinery inside cilium and near it. This picture leads to a rather detailed model of the role of phosphate in metabolism and also to a detailed model for the pairing of DNA and dark DNA (DDNA) and forces to modify the earlier model somewhat.
- (e) Also the gravitational MB of Sun could be involved, and the prediction is that the energy range for the metabolic energy quanta corresponds to the range of visible energies

so that photosynthesis could use photon energy to kick dark protons and dark electrons to the gravitational MBs of Earth and Sun to serve as metabolic energy storage.

The quantum gravitational view about metabolism leads also to a modification of the views about nerve pulse conduction [L129].

- (a) In the quantum model, the cell membrane acts as a *generalized* Josephson junction for biologically important dark metal ions. These ions are identified as gravitationally dark effective ions with gravitationally delocalized electron Cooper pairs.
- (b) The delocalization of protons and possibly also electrons to gravitational bonds provides a concrete realization of the Josephson junction model in which the ground state of the axon corresponds to a soliton sequence, which has a sequence of rotating gravitational penduli as a mechanical analog [K96]. Action potential would correspond to a soliton (or several solitons) with an opposite direction of rotation. One cannot exclude the option that the ground state corresponds to a propagating wave of small oscillation and the nerve pulse to a soliton or several solitons.
- (c) The conduction of neural signals through the myelinated portions of the axons, where nerve pulse is impossible, remains a still unsolved problem of neuroscience. The formation of dark hydrogen- and valence bonds leads to an effective ionization, which takes membrane potential below critical value for the generation of nerve pulse, which is generated in the unmyelinated sections.

The critical dynamics of microtubules (MTs) involves variation of MT length relying on $\text{GDP} \rightarrow \text{GTP}$ transition, which involves the change of MB to gravitational MB and vice versa changing the local membrane potential. Therefore MT dynamics makes possible the propagation of the action potential. The effect of anesthetics can be understood in terms of reduced density of HBs preventing the formation of gravitational HBs so that MTs and the axonal potential freeze.

- (d) A model of the pre-neural system [L129], based on the gravitational MB and the predicted electronic metabolic energy quantum, is developed in order to explain how animals without a nervous system behave as if they had the brain. These animals move using cilia/flagella, which have no mitochondria inside them or in their vicinity. This suggests that the electronic metabolism could replace the usual metabolism.

Quantum gravitation in the TGD sense also provides insights about bio-catalysis and topological quantum computation-like processes [L134, L140].

Dark-electron hole pairs as a signature of gravitational metabolism

An intriguing resemblance between the physics of electron-hole pair Bose-Einstein condensates at very low temperatures and photosynthesis have been discovered. The findings are described in a popular article at (<https://rb.gy/fnv3j>). The original article of Schouten et al [?] can be found at <https://rb.gy/b982c>. It has been observed that electron-hole pairs as quasiparticles form Bose-Einstein condensates at very low temperatures. They behave very similarly as in living matter where temperature is much higher and these Bose-Einstein condensates should not exist.

- (a) TGD predicts dark matter as phases of ordinary matter with effective Planck constant $h_{eff} = nh_0$ (n integer, $h_0 < h$) residing at field body (in particular, at the monopole flux tubes of the magnetic body (MB)) defining the TGD counterpart for classical em fields in TGD as collection of space-time sheets carrying classical fields.

The large value of h_{eff} makes these phases macroscopically quantum coherent and analogous to Bose-Einstein condensates. This leads to a variety of predictions. In particular, the magnetic body (MB) would be in a key role in living matter controlling

the ordinary biomatter and forcing it to behave coherently. The very large value of gravitational Planck constant $\hbar_{eff} = \hbar_{gr} = GMm/\beta_0$, $\beta_0 = v_0/c \leq 1$, makes possible gravitational quantum coherence at the gravitational MB and the classical gravitational fields of Sun and Earth play a key role in quantum biology: this is reflected by many magic numerical coincidences [L125].

- (b) The strange effects in the brain (the quantal effects of ELF em fields in the brain) originally led to the TGD view of dark matter, which is also predicted by the number theoretical vision of TGD. For instance, superconductivity and analogous phenomena are possible at room temperatures at MB of the system. The TGD based model of high Tc superconductivity relies on them [K93, K94, L102].
- (c) One interesting structure is a pair of a dark electron and the hole created as the electron becomes a dark electron at MB. The quantum numbers of holes and dark electrons are in 1-1 correspondence, and this could make possible a kind of quantum holography mapping the state of holes to that of dark electrons. This would provide representations of biological body (BB) at MB as kinds of sensory perceptions about the state of BB [L146].
- (d) The transfer of electrons to dark electrons can cause electronic charge fluctuations in ordinary matter due to the transfer of electrons to dark electrons at MB. For strange metals, these fluctuations have been observed: it is difficult to understand them as being caused by the attachment of electrons to atoms of strange metal since the time scale is too long (<https://rb.gy/ws51f>).

The reported experimental findings about a connection between electron-hole pair BE-condensates at low temperatures and photosynthesis can be seen as a support for the TGD view of dark matter and living systems. In particular, the TGD view would be important for understanding photosynthesis and other proposals for how quantum physics could be relevant for biology. For instance, the model for the ability of birds to navigate by utilizing the magnetic field of Earth suffers from a problem that the ordinary Planck constant is too small by a factor of order 1/100.

- (a) The TGD explanation of the new findings is in terms of the hierarchy of Planck constants labelling dark matter as phases of ordinary matter. Gravitational Planck constant $\hbar_{gr} = GMm/\beta_0$, $\beta_0 \leq 1$, labels a levels of hierarchy, which are of special importance in the TGD based model of living matter.
- (b) In TGD, one could have Bose-Einstein condensates of hole-dark electron pairs. Dark electrons would reside in a very long gravitational flux tube and would be kicked to height of order Earth radius by solar photons during photosynthesis. They would serve as a metabolic energy resource: gravitational batteries would be loaded in photosynthesis. When dark electrons drop down and transform to ordinary ones, they liberate energy which can be stored or used. ATP-ADP process could involve this dropping down.

Also dark protons could be transferred to magnetic flux tubes. This would take place in Pollack effect in which irradiation of water in the presence of gel phase leads to the formation negatively charged regions with effective stoichiometry $H_{1.5}O$. Part of protons goes somewhere and one possible place could be gravitational MB but also much shorter flux tubes for which dark proton corresponds to the size scale of DNA nucleotide are possible and would be important for the realization of dark genetic codon. Perhaps the most plausible option is that triplets of dark protons and electrons are involved in the case of metabolic energy storage.

15.2.2 The P-H theory and TGD

One could end up with the analog of Orch-OR in the TGD framework via the following arguments.

- (a) Gravitation is an unscreened long range interaction. Therefore it is plausible that it should allow quantum coherence in arbitrarily long scales. The first guess for the coherence scale in the presence of a large mass is as Schwarzschild radius $r_s = 2GM$: the analog of the quantum gravitational Compton length is indeed proportional to it. This however requires large values of Planck constants and leads to the TGD view of dark matter as $h_{eff} = nh_0$ phases of ordinary matter.

Note that in the P-H model the gravitational self-interaction energy was in a crucial role. In the proposed TGD based model for metabolism, for genetic code, and for the role MTs in the propagation of action potential, the interaction of dark electrons and protons with gravitational fields of Earth and Sun is in a key role. This suggests a strong dependence of life on the planetary environment [L129], which is not a good news for space travellers. The metabolic mechanisms relying on self-interactions would avoid this dependence.

- (b) One can indeed generalize the notion of gravitational metabolism to gravitational self-interactions for quantum critical systems of which MTs and water at physiological temperature range provide basic candidates. At quantum gravitational criticality these systems would define quantum superpositions of gravitational MBs with different values of $\hbar_{gr} = GMm/v_0$ and gravitational Compton length $\Lambda_{gr} = GM/\beta_0$, $\beta_0 = v_0/c$. β_0 is expected to have a discrete spectrum by number theoretic constraints and $\beta_0 = 1/n$ is the simplest option.

Also now the presence of a large mass M (planet, star or both) is needed in order to have large enough value of gravitational Compton length Λ_{gr} , which defines a lower bound for the quantum gravitational coherence scale.

- (c) The crucial finding is that binding energy of protons in the Earth's gravitational field is of order of the metabolic energy quantum .5 eV. A more precise model [L129] leads to the conclusion that metabolic energy quantum corresponds to 3 protons: the transfer of 3 protons through the cell membrane indeed takes place in ATP-ADP process. Also electrons give rise to metabolic energy quantum. Also the solar gravitational field gives rise to metabolic energy currency and this currency would be important in photosynthesis.
- (d) Intriguingly, the mass of a water blob of radius $17 \mu\text{m}$, the size of a neuron, equals the Planck mass. This suggests that Planck mass, rather than Planck length, is important in biology. The estimate for the gravitational energy of this water blob gives energy which is of the same order of magnitude as Coulomb energy $ZeV = 0.05Z \text{ eV}$ associated with the membrane potential. Could a cell define a gravitationally quantum coherent structure and could the changes of the gravitational self-interaction energy serve as metabolic energy quanta? The changes seem to be too small if they correspond to scalings.

Furthermore, in the case Earth, the Schwarzschild radius is .9 cm, which is a biological length scale and one has $\Lambda_{gr} = r_s/cv_0 = GM/v_0 = .45\text{cm}(c/v_0)$. One has $\beta_0 = v_0/c \simeq 1$ in a good approximation.

- (e) There are indications that β_0 is quantized to rational values. The space-time surfaces in the superposition would correspond to different values of β_0 and Λ_{gr} .

Could different space-time surfaces assignable to MBs in the superposition correspond to different values of β_0 ? $\beta_0 = 1/n$? For $n = 2$, Λ_{gr} would be scaled up by factor 2. This need not imply scaling at the level of ordinary matter but could imply it at the level of MB. $\beta_0 = 1 - 1/n$ would allow arbitrarily small scalings of Λ_{gr} .

In the TGD framework, the space-time surfaces in the superposition need not be scaled variants of the ground state space-time surface. The gravitational binding energy of long gravitational flux tubes accompanying the gravitational HBs and VBs is reduced and would serve as a local metabolic energy resource. Could the number of potential metabolic energy quanta as the number of these bonds to the integer n appearing in v_0 ?

P-H hypothesis involves the assumption that MTs are quantum systems.

- (a) There is indeed evidence for MTs as quantum coherent systems [J19, J74] discussed from the TGD point of view in [L24]. In TGD the quantum coherence would be due to metabolic energy feed taking care that dark particles decaying back to ordinary ones can be re-created [L102]. Quantal flow equilibrium would be in question.

In TGD, a related crucial element is the hierarchy of dark matters labelled by $h_{eff} = nh_0$. The gravitational Planck constant GMm/v_0 would correspond to the top of this hierarchy and make possible gravitational quantum coherence in long scales.

- (b) In the TGD framework, one expects that MTs define an important level in the hierarchy of consciousness. The criticality of axonal MTs in the sense that their lengths are continually changing could be actually quantum criticality at the level of the MB of MT. This could make MTs special since quantum criticality makes a system an ideal sensory receptor and controller. The increase of h_{eff} in turn increases the cognitive resources of the system since algebraic complexity increases.
- (c) The transfer of protons from MTs to dark protons at its MB can indeed explain why the conduction of action potentials through the myelinated sections of the axon is possible. The charge of the MT region changes and this changes membrane potential and gives rise to action potential.
- (d) The inclusion of self-gravitation could add the ability of water to serve as a metabolic energy source gravitational self-interaction energy as a metabolic energy. One might hope that this allows us to overcome the dependence of metabolism on planetary gravitational fields. In fact, only water is able to do this.

Could the following picture make sense?

- (a) Superpositions of geometries are replaced in TGD with superpositions of space-time surfaces with quantum gravitationally important modifications assignable to the gravitational magnetic body. There would be no problems with energy conservation and the new view about space-time allows us to identify also MTs as and their MBs as space-time surfaces, which are minimal surfaces with singularities analogous to soap films with frames.
- (b) A lot of new physics emerges: number theoretical physics and geometric physics related by M^8-H duality, number theoretical h_{eff} hierarchy labelling dark matter as phases of ordinary matter; gravitational Planck constant $\hbar_{gr} = GMm/v_0$ characterizing particle of mass touching gravitational flux tube; and zero energy ontology (ZEO).

- (c) The crucial point is that the huge value of \hbar_{gr} would allow to avoid the loss of quantum gravitational coherence otherwise caused by the other interactions.

For $\hbar_{gr} = GMm/v_0 > \hbar$ one must replace \hbar with \hbar_{gr} meaning that $GMm > v_0\hbar$. The TGD based quantum gravitation becomes visible for particles of mass m in the gravitational field of large mass M at flux tubes with $GMm/v_0 > \hbar$. The gravitational Compton length $\Lambda_{gr} = GM/v_0 = r_s/2v_0$ does not depend on m and for Earth one has $\Lambda_{gr} = .45 \text{ cm}/(v_0/c)$, which is a biological scale. Cyclotron frequencies for a charged particle with mass m are also independent of m . Josephson frequency $f_J = ZeV/\hbar_{gr}$ is dramatically smaller than for ordinary \hbar and corresponds to ELF frequency in the case of cell membrane.

- (d) Gravitational variants of hydrogen bonds (HBs) and valence bonds (VBs) as long U-shaped flux tubes are part of picture. Liberation of metabolic energy as an increase of gravitational binding energy as very long dark gravitational HB or VB becomes short. Metabolic energy quanta come as protonic and electronic variants differing by factor m_p/m_e . The masses of Earth and Sun have a central role. Also other masses involved but the proportionality of \hbar_{gr} to M means that these are the most important ones.

- (e) Gravitational energy difference would be roughly $\Delta GMm/R$ for a long gravitational flux tube associated with dark HB (VB) and short tube and corresponds to metabolic energy associated with the long HB (VB). A rough guess for the metabolic energy would be about .5 eV for proton. This would give time of order 10^{-14} sec corresponding to an energy of IR photon. For electron the metabolic energy in the meV range. A more careful estimates increase the number of protons and electrons to 3.

This would suggest that the space-time surfaces in the superposition correspond to space-time surfaces with various numbers of potential metabolic energy quanta. These space-time surfaces are *not* scaled versions of the ground state space-time surface as in the GRT picture but analogous to the deformation of the surface of Earth by the presence of biosphere such as plants and trees. By fractality, this kind of magnetic forests of U-shaped flux tubes would appear in all scales and first emerged in the model of atomic nucleus carrying quarks.

In order to get some grasp on the new idea, one can play with numbers.

- (a) One can consider the analog of the P-H hypothesis $\tau = \hbar/E_g$ as $\tau = \hbar_{gr}/E_g = \hbar/R$ in the case of the gravitational flux tubes of Earth with size scale R determined by Earth radius R_E .

The time scale corresponding to dark proton flux tube of length of order Earth radius $R_E \sim 6.37 \times 10^6$ m would be $R_E/(v_0/c)$ and would give $\tau = 21$ ms for $\beta_0 = v_0/c = 1$. The time scale of nerve pulses is a few ms.

- (b) Also gravitational Compton time should have relevance. For $\beta_0 = 1$ one has $\tau = GM/c = r_s/2c$. For Earth this would give $\tau = 1.7 \times 10^{-11}$ s. For ordinary Planck constant this corresponds to an meV energy scale. So called miniature end plate potentials .4 mV (<https://cutt.ly/HSJIn76>) have this scale.

15.2.3 Could the space-time surfaces in the superposition correspond to different scalings?

The change of gravitational interaction energy should not be random and should be such that the changes of gravitational energy are of the same sign for all particles. The interpretation of the parameter R as a shift does not look plausible.

This does not leave many options in the GRT framework. The change of the gravitational interaction energy could be induced by a scaling also in TGD framework, but most naturally at the level of gravitational MB as scaling of magnetic flux tube thickness, whose thickness is naturally proportional to \hbar_{gr}/\hbar . This would conform with the underlying scaling invariance of TGD so that R should be replaced by a dimensionless scaling parameter $\Lambda - 1$.

- (a) Scalings are indeed natural in the TGD framework, where the analog of time evolution is assigned with scaling rather than time translation and p-adic thermodynamics with conformal weight rather than energy so that a discrete superposition of scaled variants of space-time surface would make sense. One option is that scalings correspond to different p-adic primes, perhaps near to each other. Scalings by say powers of 2 suggested by p-adic length scale hypothesis could make sense at the level of visible matter in critical situation involving large density fluctuations (as in the evaporation). In this case the quantum criticality of MB could induced criticality of the ordinary matter.

The scaling of flux tube thickness could correspond to that for the universal particle independent gravitational Compton length $\Lambda_{gr} = GM/v_0$ induced by the change of the velocity parameter as $\Delta v_0/v_0 \Delta \Lambda$. Small scalings would be possible and they would be realized for dark particles at gravitational flux tubes. Note that this requires the presence of a heavy astrophysical object such as a star serving also as a metabolic energy source.

- (b) The scale change would be proportional to the change of the scaling parameter $\Lambda - 1 = \Delta\Lambda$. In the P-H model, the estimates for the separation scale R , whose interpretation seems to be as a shift, vary between nucleon size scale and size scale of tubulin protein (10 nm).
- (c) A simple estimate shows that for 10^{11} tubulins assignable 10 m long axon containing 13×13 tubulins per length of about 10 nm, the scale of gravitational self-interaction energy is of order 10^{-16} eV so that the interpretation of a reduction of gravitational binding energy for an analog of Orch-OR as a potential metabolic energy is excluded. The mechanism proposed in [L129] is the only possible mechanism involving only MTs (plus the gravitational field of Earth to make Λ_{gr} large enough).
- (d) For the TGD based quantum gravitational model of metabolism E_g has a scale of metabolic energy quantum and is many orders of magnitude larger than allowed by the constraint if it defines a time scale in a range 5 sec- 10^{-2} sec. For ordinary Planck constant, one would have $\tau \sim 10^{-13}$ sec. In the TGD framework $\hbar_{eff} = \hbar_{gr}$ implies $\tau = \hbar_{gr}/E_g$. For the Earth's mass, the time scale would be the desired one. This supports the hypothesis that cell interiors consisting of ordered water define gravitationally quantum coherent regions and the surfaces in the superposition differ by the number of gravitational HBs and VBs.

The metabolic mechanism based on gravitational HBs and VBs imply the dependence of life on planetary gravitational fields. However, metabolic autonomy could be of high relevance for the life on other planets and also for space travel (this is discussed from the TGD point of view in [L129]). Also the possible proto cells in interplanetary space could use a metabolism based on gravitational self-energy. The presence of a nearby star seems however necessary to guarantee that the quantum gravitational coherence scale $\Lambda_{gr} = GM/v_0$ is long enough. For biological systems, such as cells, it is extremely small.

Could the gravitational self-interaction energy of water serve as a source of metabolic energy and allow to circumvent this dependence?

- (a) Consider first the cell scale. Water blob of Planck mass $M_{Pl} = 2.2 \times 10^{-8}$ kg has size $R \simeq 1.74 \times 10^{-4}$ m, which corresponds to the size of a large neuron. In this case, one has $E_g = \Delta E = [\lambda - 1]/\lambda E_g$, $E_g \simeq GM^2/R \sim 7$ meV. Maximum energy gain is 3.5 meV, which is roughly 10 times the energy scale of miniature potentials and is by a factor of 10 smaller than the Coulomb energy scale $\sim .05$ eV assignable to the membrane potential. The energy scale corresponds however to the difference of Coulomb energies of cell membrane for opposite values of membrane potential.

If the system is critical so that large density fluctuations inducing the scaling of R and preserving M are possible, the scaling parameter $\Delta\Lambda$ characterizing the possible changes of water volume can be large. In this case, one could consider the possibility that some kind of metabolic energy needs could be satisfied.

- (b) Could larger water blobs, say those assignable to muscles, which indeed experience scale changes, help? For the entire body of mass of 50 kg and size scale of $R = 1$ m, the estimate for gravitational self-interaction energy is of order 6.4×10^{12} eV, which is about 10^{-6} J: lifting a weight of 1 kg to a height of 1 m requires 10 J. This option does not look realistic. Note also that the liberated metabolic energy feed cannot be targeted in a precise way.
- (c) Just for fun, one could also consider the entire biological body with (say) size $R = 1$ m and mass $M = 50$ kg and regard cells with mass of order Planck mass m_{Pl} as the dark particles at the flux tubes of its MB. The flux tubes connecting cells to each other would be stretched to gravitational flux tubes of length of roughly body size R . This option would allow a targeting of the metabolic energy by transforming the dark cell back localized to the biological body.

The estimate for the order of magnitude of a metabolic energy quantum $E = GMM_{Pl}/R$ for MB flux tubes of size R would be $E \sim .25$ eV, one half of the value of the metabolic

energy quantum. As will be found, the change of the sign of the membrane potential involved with an action potential requires energy of 3.5 meV and this energy could be generated already by a mass $M \sim .5$ kg.

15.2.4 Could the TGD analog of Orch-OR make possible an action potential for protocells?

The idea about gravitational superpositions of space-time surfaces related by scalings looks interesting since the scalings could relate to the scaling of the parameter β_0 in $\hbar_{gr} = GMm/v_0$ and in Λ_{gr} in the case that the flux tubes correspond to the mass of Earth or Sun.

For the masses M of say living organisms Λ_{gr} is extremely small. The presence of a stellar object, having a gravitational field characterized by $\hbar_{gr} = GMm/v_0$ and $\Lambda_{gr} = GM/v_0$, is needed in order to have quantum gravitational coherence in biologically interesting scales.

Quantum gravitational phase transitions of water blobs as the TGD counterpart of Orch-OR?

Instead of Orch-OR, quantum gravitational phase transitions are suggestive in the TGD framework. The quantum gravitational superpositions would be associated with quantum phase transitions changing Λ_{gr} and perhaps also inducing a scaling of the system consisting of ordinary matter. This scaling would mean large density fluctuations affecting the gravitational self-interaction energy.

- (a) Ordered water forming a gel-like phase in the presence of biomolecules is a natural guess for what gravitationally quantum coherent phase could be. A membrane-like object separating proto-cell from environment is needed to create a volume of water with quantum gravitational coherence.

2-D membrane-like objects with 1+2-D M^4 projection, possibly pairs of them forming double membranes, appearing in these scales could serve as templates for membrane-like objects, which could have preceded cell membrane and also for the recent cell membrane. Their presence could have led to the emergence of lipid layers, which involve only hydrocarbons. These membrane-like objects form a fractal hierarchy and could accompany both galactic and planetary planes as walls and also the biosphere at the surface of Earth serving as analog of the cell membrane.

- (b) p-Adic length scale hypothesis and the number-theoretically miraculous appearance of 4 Gaussian Mersenne primes $L(k) \simeq 2^k$, $k = 151, 157, 163, 167$, between the cell membrane length scale and cell nucleus scale suggests that gravitational quantum coherence in these scales is involved.
- (c) Protocell as a pair of 2 membrane-like objects and as a template of cell membrane could define electric flux quantum as a counterpart of magnetic flux quantum. It would have carried an electric field as an analog of capacitor plates.

If the electric voltage is absent, only mechanical work is possible. The energy scale in mechanical thermodynamic degrees of freedom is however huge as compared to the energy scale in gravitational self-interaction energy degrees of freedom so that the change of gravitational self-interaction energy to mechanical work in the cellular scale is not possible.

Pollack effect [L25] caused by the stellar radiation could have generated the negative charge to the interior of the inner membrane. In principle, this requires the presence of only water.

- (d) One can imagine that the value of \hbar_{gr} characterized by the value of β_0 and associated with the stellar gravitational flux tubes, fluctuates locally and generates scaled variants of gravitational flux tubes in turn inducing density fluctuations and the thermodynamical criticality of water. Fluctuations would produce water regions with a reduced density analogous to a vapour phase.

- (e) The liberated self-interaction energy would be $E_{gr} \simeq (\lambda - 1)GM^2/R$, where R is the size of the water blob, and scales like R^5 . λ is the scaling inducing also the scaling of $\Lambda_{gr} = GM/v_0 \rightarrow \lambda\Lambda_{gr}$.

At quantum criticality, assumed to induce thermodynamic criticality, the change of the free energy would be very small for the values of scalings in the superposition. The first guess is that by the quantization of $\beta_0 = 1/n$, one has $\lambda = n$. $n = 2$ gives 2-adic scaling and p-adic length scale hypothesis favoring $p \simeq 2^k$ could relate to these phase transitions. This picture makes sense if the criticality is analogous to that of boiling water.

For a water blob of Planck mass with $\beta_0 = 1/n$, the gravitational metabolic energy gain is below 3.5 meV, which corresponds to the miniature potential.

- (f) As already found, the gravitational self-interaction energy cannot be used to perform mechanical work in practice. Since the energy gains are in the meV range, a more promising option is that the energy goes to a creation of a pre-neuronal action potential. By the arguments of [L129], the metabolic energy quantum for electron based metabolism is of order .25 meV and miniature potentials about .4 meV. Action potentials are possible already for mono-cellulars and one can ask whether even a proto-cell could generate the analog of an action potential without the ATP-ADP machinery.

The scaling of the volume as a phase transition at quantum criticality could be present also in recent biology and one can wonder if the swelling of cells during infection could relate to this process.

Could the generation of gravitational self-interaction energy give rise to action potential?

The generation of gravitational self-interaction energy of a water blob with Planck mass liberates energy. Could it have given rise to an analog of action potential?

- (a) The gravitational self-interaction energy is of order $E_{gr} = GM^2/R$ and as a function of R scales like R^5 so that it is rather sensitive to the value of R . Already the scaling of R from 10^{-4} m by factor 3.1 transforms metabolic energy quantum of 3.5 meV to .5 eV.

For a fixed M , E_{gr} scales as $1/R$. The analog of Orch-OR would be following. A superposition of different scalings of a water blob would be created much like in evaporation. After that a phase transition leading to a less dense state with definite scaling would take place. This requires metabolic energy provided by a near enough star. The phase transition back to the original situation takes place and liberates the metabolic energy.

- (b) When an action potential is generated, the membrane potential changes sign. In ZEO this could correspond to two BSFRs, each of which changes the arrow of time. The change for the arrow of time corresponds naturally to the sign change of V .

The change of energy in this process is $2QV = 2e^2V^2S/d$, eV corresponds to the Coulomb energy of membrane potential, $Q = ES = VS/d$ is the charged assumed to be conserved in the transition, $S = 4\pi R^2$ corresponds to the area of cell membrane. Charge conservation gives $V = d/S$. The natural scaling is $d \rightarrow \lambda d$ and $S \rightarrow \lambda^2 d$, which gives $V \rightarrow V/\lambda$.

For $R = 10^{-4}$ m corresponding to Planck mass (large neuron size), $d = 10$ nm, and $V = .05$ V, the change of Coulomb energy of the membrane would be $\Delta E \simeq 6.3$ meV. The upper bound for the change of the gravitation binding energy was 3.5 meV corresponding to a scaling of 2. It would seem that the gravitational phase transition as a 2-fold scaling and its reverse could induce a proto version of the action potential.

15.2.5 How water blobs could have evolved into living organisms?

Quantum gravitational criticality could be assigned to water blobs. In interstellar space the possible metabolism would not depend on the planetary gravitational flux tubes but would depend on the mass M of the nearest stellar object. Stellar gravitational fields are indeed necessary for large enough gravitational Compton length GM/v_0 .

Important facts about water

Consider a water blob of radius R . The phase diagram of water (<https://cutt.ly/EKx9nGX>) allows to understand how thermodynamic criticality under normal conditions and during the prebiotic period could differ. There are two different situations to consider. When the pressure is above tricritical pressure P_{cr} , water allows liquid phase. Below P_{cr} , only solid and vapour phases are possible.

- (a) The normal physiological situation with normal pressure $P_{phys} = 1$ atm (101.325 kPa) in the vicinity of physiological temperature around $T_{phys} = 37$ C, which is between the freezing point and evaporation point. This kind of criticality could have been present for pressures above the tricritical pressure along a critical line.

The numerous thermodynamic anomalies of water suggest that it is quantum critical at the physiological temperature range between solid-liquid phase transition and liquid-gas phase transition. The temperature for this range is above $T = 0$ C. Quantum criticality would give rise to superposition of phases with different density and differing by scaling above the tricritical point.

Solid-liquid critical curve would naturally correspond to quantum criticality. Could some kind of life forms be associated with this criticality?

- (b) Below the tricritical point, the liquid water phase is absent so that the counterpart of the physiological quantum criticality is not possible. If the pressure is below $P_{cr} = 611.657$ Pa $\simeq .006P_{phys}$ and temperature below $T_{cr} = 0.01$ C, only solid and vapour phase are possible and criticality would be associated with the curve at which sublimation of ice takes place.

In particular, the situation with $T \simeq 30$ K would correspond to a very early prebiotic phase, when the age of the Universe was about 1 Gy and the cosmic temperature was about 30 K. In this situation, quantum criticality could relate to the sublimation and the density fluctuations associated with it and would involve a superposition of scaled variants of H_0^2 blob.

Snow flakes, Emoto effect, and Pollack effect: life at quantum criticality?

Suppose that solid-liquid solid-vapour critical curves correspond to quantum criticality. Could some kind of life forms be associated with these quantum criticalities?

- (a) Snowflakes (<https://cutt.ly/sKJclSy>) are amazingly ordered structures and appear in freezing and direct solidification of water vapour. Snow flakes do not have metabolism. Could snowflakes be "corpses" of life forms emerging at quantum criticality?

The experiments of Masaru Emoto [L78], discussed from the TGD point of view in [L78], demonstrate that if water at freezing point is subject to sound signals, it generates freezing patterns, which can be extremely beautiful or ugly depending on the emotional content than human would associate to the signal. Emoto suggests an interpretation in terms of expression of emotions generated by the sounds.

- (b) In the TGD framework, a model of harmony leads to a model of genetic code [L22] [L96]. Genetic codons would consist of 6-bit codons realized also as 3-chords

represented by 3 dark photons and by dark 3-proton states. The harmony is defined by 3 icosahedral Hamiltonian cycles, each representing a 12-note scale, plus the unique tetrahedral Hamiltonian cycle. The 3-chords define a bioharmony with 64-chords realized as dark photon triplets. Since ordinary harmony of music induces and expresses emotions, the proposal is that a given bioharmony defines an analog of mood already at the level of basic information molecules.

- (c) Could a dark realization of the genetic code be involved with the criticality of water and explain the high information content of snowflakes and the findings of Emoto? Snowflake has a locally violated 6-fold rotational symmetry and looks like a planar tree with branches emanating from the center. That one cannot find two identical snowflakes, can be understood in terms of criticality during their formation.

Icosahedron and tetrahedron correspond to an icosahedral symmetry group with 60 elements and hexagon to Z_6 . All these groups belong to an infinite hierarchy of discrete and finite subgroups of $SU(2)$ associated with the inclusions of von Neumann algebras known as hyper-finite factors of type II_1 [K141, K51]. $M^8 - H$ duality allows us to interpret $SU(2)$ as a covering group of the automorphism group of quaternions.

- (d) The dark proton realization genetic code would be in terms of ico-tetra-tessellation of hyperbolic 3-space H^3 (light-cone proper time constant surface) [L108]. Ordinary ice I_h consists of hexagonal layers (<https://cutt.ly/sKJcveh>): could a hexagonal tessellation at the level of H^3 could be involved. This suggests that if the genetic code is realized at the level of MB, a symmetry breaking leading from an ico-tetra-tessellation to a hexagonal tessellation at the level of ordinary matter takes place in the freezing of water.
- (e) Intriguingly, the size scale of the snowflake hexagon is of order .45 cm, which happens to be the gravitational Compton length $\Lambda_{gr} = GM_E/v_0$ in the gravitational field of Earth for $v_0 = c$ determined from other arguments [L115]! This scale is huge as compared with the size of order 1 Angström of the ice crystal hexagon. Quantum fluctuations at quantum criticality involve however large values of h_{eff} meaning scaled up sizes for the basic structures. For $h_{eff} = h_{gr}$ the minimum size would naturally be Λ_{gr} ! Note that the thickness of human cortex varies in the range .1-.45 cm.
- (f) The fourth phase of water, as Pollack calls it, is formed in the Pollack effect [I126, L25, ?, ?] and consists of hexagonal layers connected by hydrogen bonds. The effective stoichiometry is $H_{1.5}O$ so that every fourth proton goes somewhere and a negatively charged exclusion zone (EZ) is formed. In the TGD based model, every fourth proton becomes a dark proton at flux tube so that the stoichiometry becomes $H_{1.5}O$.

Dark protons with $h_{eff} = h_{gr}$ would not be present for snowflakes nor for the crystal-like structures studied by Emoto. However, at the quantum criticality for freezing they could emerge and be associated with quantum gravitational hydrogen bonds (flux tubes) containing dark protons delocalized in the Earth size scale [L129, L134].

The basic claim of Emoto is that water at criticality has emotions and expresses them. If bioharmony determines emotions and is realized in terms of dark proton and dark photon sequences at quantum criticality, the question arises whether a dark realization of the genetic code for snow flakes and whether the MB controls and communicates with water using dark 3-photons. Conditioned learning is based on emotions: could water at criticality be able to learn in this way?

If quantum criticality is the prerequisite of life, one can ask whether snowflakes of the crystal structures of Emoto could be "revived" by bringing the water to criticality.

- (g) At least for water, silicon, gallium, germanium, bismuth, and plutonium, the density is higher for liquid phase than solid phase above criticality. Could all substances with this property show analogs of Pollack and Emoto effects? Or could these effects appear universally at melting and sublimation curves. What about the analogs of snowflakes with size $\Lambda_{gr} \sim .45$ cm?

Strange coincidences related to gravitational Planck constant, basic biorhythms, membrane potential and metabolic energy currency

It is becoming clear that the gravitational quantum coherence is central for life on Earth. The hierarchy of Planck constants $\hbar_{eff} = n\hbar_0$ involves special values, in particular gravitational Planck constants $\hbar_{eff} = \hbar_{gr} = GMm/\beta_0$, where M is a large mass (say mass of Sun or Earth) and m is small mass (say mass of electron or proton) and $\beta_0 = v_0/c \leq 1$ is velocity parameter, are of key importance for living matter. Particles with a different value of \hbar_{gr} correspond to different gravitational flux tubes and the value of β_0 can depend on the particle.

There are several amazing numerical coincidences supporting this view.

- (a) For Sun one has $\beta_0 \simeq 2^{-11}$ which happens to be rather near to the electron proton mass ratio m_e/m_p . The condition $\hbar_{gr}(M_S, m_p, \beta_0(Sun)) \simeq m_e/m_p = \hbar_{gr}(M_S, m_e, \beta_0 = 1)$ would guarantee resonance between dark photons generated by the solar gravitational flux tubes assignable to protons and electrons.
- (b) In accordance with Equivalence Principle, the gravitational Compton length $\hbar_{gr}(M_S, \beta_0)/m = GM/\beta_0 = r_S/2\beta_0$ is independent of m for Sun $GM_S/\beta_0(Sun)$ is rather near to Earth radius. For Earth one has $GM_S/\beta_0(Earth) \simeq .45$ cm which corresponds to the size scale of the somewhat mysterious snowflake analogous to a zoom-up of a basic hexagonal unit cell of ice crystal. There is evidence for $\beta_0(Earth) = 1$ in hydrodynamics, in particular from the TGD based model [L115] for the observed hydrodynamical quantum analogs described in an article of Bush et al [D12] (see <https://cutt.ly/nEk50LA> and <https://cutt.ly/xEk5Api>)
- (c) The gravitational Compton length of the galactic blackhole corresponds rather precisely to the $n = 1$ Bohr orbit associated with the Sun. This suggests gravitational quantum coherence in the scale of the galaxy.

In the following some additional strange coincidences are discussed. It would be very natural if the basic biorhythms defined by the duration $T_d = 24$ hours of day and the duration of year $T_y = 365$ days would correspond to energies of dark photons $E = \hbar_{gr}f$, which are biologically significant energies. The potential energy $eV_c \simeq .05$ eV associated with the cell membrane defines Josephson energy in the TGD inspired model of cell membrane. Metabolic energy currency with the nominal value of .5 eV is second important energy. Could the periods of fundamental bio-rhythms, fundamental biological energies, and the gravitational Planck constants for Sun and Earth correlate?

The above assumptions imply that one has $\beta_0(Sun)/\beta_0(Earth) \simeq m_e/m_p$ and $\hbar_{gr}(Sun, m_e)/\hbar_{gr}(Earth, m_p) \simeq M(Sun)/M(Earth)$. The value of Sun-Earth mass ratio is $M_S/M_E \simeq 6 \times 10^5$.

- (a) The corresponding frequency corresponding to the basic biorhythm $T_d = 24$ is $f_d = 1/G_d = 1/24\text{hours} = [1/(2.4 * 3.6)]10^{-6} \simeq 1.1^{-6}$ s. The corresponding Josephson energy would be $E(\hbar_{gr}(Sun, m_e), f_d) \simeq .06\text{eV} = E_J$. This is very near to the Josephson energy E_J for cell membrane potential!
- (b) For $T_y = 1$ year = 365 days one has $E(\hbar_{gr}(Sun, m_p), f = 1/T_y) \simeq (m_p/m_e) * (24 \text{ hours/year}) \times E_J \simeq (2^{11}/365)E_J \simeq .33\text{eV}$. This is not far from the value of the metabolic energy currency near to .5 eV.

Metabolism of the protocell above tri-criticality

Consider first the situation above tricriticality, when liquid water and perhaps also the counterpart of physiological quantum criticality was possible.

- (a) The temperature is above tricritical temperature $T = .01$ C (<https://cutt.ly/EKx9nGX>). The frequency distribution of thermal photons has a maximum at energy .131 eV at this temperature. This energy corresponds to a Josephson energy of a Cooper pair for

membrane potential of .066 eV. The membrane potential varies in the range .04-0.08 eV.

Note that the electronic variant of the gravitational metabolic energy quantum is about .25 meV, which might explain the metabolism of cilia [L129], is of the same order of magnitude as the thermal energy of CMB now.

- (b) According to the TGD view, biochemistry involves quantum gravitation at the level of dark hydrogen bonds and requires the presence of gravitational fields of both Earth and nearby Sun. In the interstellar space ATP-ADP machinery and its possible electronic counterpart [L129] would have been absent and only gravitational self-interaction energy of the water blob could have served as a metabolic energy source receiving its energy.

Stellar radiation could feed energy to the quantum gravitational degrees of freedom of the proto cell, in particular in the range of visible energies. The gravitational energy could in turn be feeded to the degrees of freedom of the protocell. Hydrogen bonded structures involving dark HBs could receive this energy as a metabolic energy.

Could cosmic microwave background have served as metabolic energy source for prebiotic life-forms?

In the prebiotic phase at interstellar space the temperature was very low and the water blobs were below tri-criticality so that the liquid phase was absent. Therefore quantum criticality could relate to the sublimation of ice.

Stars are a possible source of metabolic energy but what about the cosmic microwave background as a heat bath providing metabolic energy for water blobs as prebiotic life forms?

- (a) Energy 3.5 meV assigned with the action potential corresponds to $T \simeq 35K$, which is roughly $T_{phys}/10$, and near to the temperature of the cosmic microwave background in the early Universe with age about 1 Gy. There is evidence that important biomolecules were present already at this time although chemistry should have been frozen. A TGD based explanation of this finding has been considered in [L127].
- (b) Could the heat bath defined by the cosmic microwave background (CMB) have served as a source of metabolic energy in the interstellar space during the prebiotic period providing the energy needed to induce action potential? The periodic generation of the action potential as a sequence of pairs of BSFRs would be analogous to breathing or sleep-awake cycle [L124].

During the sleep period, the water blob would dissipate with a reversed arrow of time and effectively extract thermal energy from the environment. During the wake-up period after BSFR, the blob would dissipate this energy to both internal and external degrees of freedom. The blob would also receive energy from the CMB background serving as a heatbath. The energy dissipated in the internal degrees of freedom would have served as a metabolic energy driving self-organization and gradual chemical evolution in the presence of carbohydrates and atoms needed by the basic organic molecules.

15.2.6 Could quantum criticality make microtubules very special?

MTs are regarded as very special in P-H theory. Their role at the level of the brain indeed seems to be very special. Why should MTs be so special from the point of view of consciousness?

Quantum criticality is the key feature of the TGD Universe, in particular that of living matter. Quantum criticality makes possible quantum fluctuations and long range correlations at the level of MB realized as a superposition of phases with varying value of $h_{gr} = GMm/v_0$ and therefore of scaled variants of MBs. Space-time surface in the superposition would correspond to slightly different values of v_0 .

MTs are critical systems in the sense that their length fluctuates wildly and their decaying region expands also in transversal directions. This fluctuation could reflect a superposition of quantum critical dark matter at MB with varying values of $h_{eff} = h_{gr}$ and thus different size scales of flux tubes proportional to h_{eff} .

The variation of the flux tube scale would be proportional to $\Delta v_0/v_0$ and, as already proposed, presumably quantized by number theoretical reasons. $\beta_0 = 1/n$ is perhaps the realistic option. The changes of MT lengths could have an interpretation as being induced by the scalings of MB of MT with respect to origin near the passive end of MT so that the scaling would be largest at the active end.

15.3 Appendix: Quantum gravitational decoherence as a way to test the Diosi-Penrose model

The approach of Donati et al [D17] to test the Penrose-Diosi variant of the Orch-Or [J61] model yielded a null result. In the sequel, the Diosi-Penrose model is discussed from the point of view of standard quantum theory predicting the negative outcome and the experiment of Donati is summarized. Also the TGD view of the situation is briefly described.

15.3.1 Brief summary and criticism of Penrose-Diosi model

A natural starting point idea would be that ordinary quantum coherence induces quantum gravitational coherence.

- (a) Quantum superposition of 3-geometries dictated by mass distributions of particles defined by particle wave functions. The wave function of the many-particle system is a superposition over configurations with localized particles and each configuration corresponds to a superposition of gravitational potentials defining gravitational self-energy.
- (b) In general relativity, this superposition corresponds to a point in the space of 3-geometries, the superspace of Wheeler consisting of 3-geometries. Therefore quantum gravitation is unavoidable and quantum coherence for matter dictates that for the gravitation. Therefore ordinary quantum theory forces quantum gravitation in the counterpart of the superspace.

In this view, the rate of quantum gravitational decoherence corresponds to the rate of ordinary quantum coherence: this conforms with Einstein's equations and Equivalence Principle.

- (c) It is essential that one has a many-particle system. For a single particle system the gravitational self-energy is the same for all positions of the particle and does not depend on the wave function at all. Even for many particle systems, the superposition of shifted systems have the same gravitational binding energy.

In the Penrose-Diosi model, it is however proposed that the above argument works for single particle and gravitational interaction energy is estimated by assigning to wave function an effective 2-particle system.

The underlying reason for this assumption is the idea that the notion of wave function and therefore also wave function collapse somehow reduces to classical gravitation.

This argument predicts a null result in any experiment trying to demonstrate gravitational quantum coherence in the sense of Penrose-Diosi.

15.3.2 Could one measure the rate of gravitational quantum decoherence in the Penrose-Diosi model?

In the Penrose-Diosi model [J61], the quantum gravitational coherence can in principle be detected by measuring the rate for gravitational quantum decoherence.

- (a) Quantum gravitational decoherence for a wave function representing a superposition of mass distribution and a shifted mass distribution is considered.

The idea is gravitational quantum coherence could be detected if the corresponding quantum decoherence occurs faster than other forms of decoherence. The basic objection is that the Equivalence Principle states that the two decoherences are one and the same thing.

If the gravitational coherence time is short enough but not too short, this might be possible. Limits for the decoherence time τ_{gr} are proposed and are between millisecond and second: these are biologically relevant time scales.

- (b) Gravitational quantum decoherence time τ_{gr} is estimated by applying Uncertainty Principle: $\tau_{gr} = \hbar/\Delta E_{gr}$. ΔE_{gr} is the difference between the gravitational self-energy for a system and a shifted system.

One has actually a superposition of different classical configurations each inducing a classical gravitational field. Wave functions for particles of *many-particle state* define the gravitational superposition. Gravitational superposition coded by a wave function for a large number of particles. In this case, gravitational binding energies E_{gr} ΔE_{gr} between 2 different quantum states are well-defined.

One could take atomic physics as a role model in the calculation of the change of the gravitational potential energy. Coulomb energy would be replaced with gravitational potential energy.

- (c) With a motivation coming from the notion of gravitational wave function collapse, one however considers *single particle* states obtained as a superposition of $\Psi(r)$ and its shift $\Psi(r+d)$. In this case, the gravitational interaction energy is not well-defined unless one defines it as a gravitational self-interaction energy, which however does not depend on the position of the particle at all and is same for local state and the bilocal state.

Penrose suggests that the difference between gravitational interaction energies makes sense and can be estimated *classically* using effective mass densities $m|\Psi^2|(r)$ and $m|\Psi(r+d)|^2$ instead of $\Psi(r)$ and $\Psi(r+d)^*$. One seems to think that one has effectively a two-particle system and calculates the gravitational interaction energy for it. To me this looks like treating a delocalized single-particle state as a two-particle state.

- (d) The situation could be simplified for a superposition of a macroscopic quantum state, say B-E condensate, and its shift. One could try to detect decoherence time τ for this situation. Now however the fact that B-E condensate is effectively a single particle, suggests that the change of the gravitational self-interaction energy vanishes.

- (e) It turns out that it is not possible to find parameter values which would allow a test in the framework of recent technology.

The intuitive idea is that the gravitational SFRs localizing the wave functions effectively induce instantaneous shifts of particles. For charged particles this induces accelerated motion and emission of radiation. This radiation might be detectable. The implicit assumption is however that a single particle state effectively behaves like a 2-particle state as far as gravitation is considered.

No evidence for this radiation and therefore for gravitational SFRs is found.

One can represent several critical arguments against the Penrose-Diosi model besides the argument represented in the beginning.

- (a) The reduction to a single particle case does not make sense in standard quantum physics (Penrose suggests something different). The gravitational self-interaction energy is the same for both shifted single particle states for any single particle wave function. For many-particle states the situation would change.
- (b) The radiation should have wavelength λ of order of the shift parameter d . d is expected to correspond to atom size or nuclear or nucleon size in the case of atoms. The energies for photons would be above 10^4 eV. These energies are suspiciously large. Much larger shifts would be required but these are not plausible for the proposed mechanism.
- (c) Why shifted mass distributions are assumed? Even in the case of many-particle systems the gravitational self-interaction energy does not depend on wave function if the system is only shifted. The reason is that the relative positions of particles are not changed in the shift.

If one uses many-particle states, a superposition of scaled mass distributions would be more natural in the standard quantum physics framework. A coherent, easy-to-calculate, change of the gravitational interaction energy. A possible connection with density changing phase transitions, such as melting and boiling, emerges. Water is a key substance in living systems!

15.3.3 The approach of Donadi et al

The model proposed by Donadi et al is as follows.

- (a) A many-particle state with delocalized single particle wave functions induces superposition of 3-geometries shifted with respect to each other. Now a superposition of a quantum coherent state and its spatial shift is considered.
- (b) The estimation for the gravitational decoherence time τ for Orch-OR from Uncertainty Principle: $\tau \sim \hbar/\Delta E_{gr}$. ΔE_{gr} is quantum uncertainty of the gravitational binding energy. Change in the gravitational self-interaction energy in the formation of superposition of shifted configurations.
- (c) One must calculate the average value of the binding energy for a single particle state effectively regarded as 2-particle state. The outcome is finite. ΔE_{gr} is assumed to be effectively the change of classical self-interaction energy for a mass density $\rho = m|\Psi|^2$, m the mass of the particle. Ψ can be solved from Schrödinger Newton equation. Point-like particle is replaced with the wave function of the particle defining a mass density.

How could one test the model? There are two approaches.

Direct measurement of gravitational decoherence time τ_{gr} is not possible

Gravitational decoherence should be faster than ordinary so that ordinary causes of decoherence are not yet active. Could one find such a system and be able to measure τ_{gr} .

- (a) A direct test of the equation of τ requires creating a large superposition of a massive system, to guarantee that τ_{gr} is short enough for the collapse to become effective before any kind of external noise disrupts the measurement.
- (b) Penrose and collaborators suggested a setup for creating a spatial superposition of a mirror of mass 10^{-12} Kg that has a decay time of order $\tau_{gr} \sim 0.002 - 0.013$ s, which is competitive with standard decoherence times.
- (c) The major difficulty in implementing this and similar proposals consists in creating a superposition of a relatively large mass and keeping it stable for times comparable to τ_{gr} .

- i. To give some examples, the largest spatial superposition so far achieved is of about 0.5 m, but the systems involved are Rb atoms (mass $m = 1.42 \times 10^{-25}$ Kg), which are quite too light.
- ii. In matter-wave interferometry with macromolecules states are delocalized over distances of hundreds nm, and masses beyond 25 kDa (10^{-23} Kg), still not enough. Mass too small!
- iii. By manipulating *phononic* states, collective superpositions of estimated 10^{16} carbon atoms (mass $\sim 10^{-10}$ Kg) are created over distances of 10^{11} m, coherence scale is about 10^{-5} meters, neuron size. The life-time of phonons is of order 10^{-12} s, which is too short. 2 ms is the lower bound for τ .

What does this mean? A superposition of wave functions with mean positions differing by 10^{-11} m define mass densities? Coherence scale 10^{-5} m.

These numbers show that keeping the measurement of τ is beyond the reach of recent technologies.

Could Brownian-like diffusion as a side effect allow the detection of gravitational wave function collapses?

The assumptions of the model of Donadi et al [D17]) are as follows.

- (a) Penrose-Diosi model is assumed and single particle states are considered. Gravitational wave function collapse is Poissonian: collapses occur independently.
- (b) Lindblad dynamics for the density matrix ρ of the system is assumed. Gravitational decoherence implies non-unitary dynamics. The form of the decoherence term is dictated by the difference between gravitational self-interaction energies. $Tr(\rho\rho^2)$ increases with time. Diffusion would heat the system. The size scale range $R_0 = 10^{-14} - 10^{-15}$ m for the system experiencing gravitational collapse is excluded experimentally.
- (c) This leaves however dissipative effects. One can argue that the collapse induces an emission of radiation by charged particles since effectively the charged particle is in instantaneous motion during the collapse. In collapses particles are randomly moved and radiate. The wavelength λ of the radiation is smaller than charged particle size: atom size or even nuclear or nucleon size.

The first criticism is that one has a single particle state and according to the standard view gravitational self-energy does not depend on the wave function. The second criticism is that the scale of energies of photons is huge as compared to intuitive expectations for gravitational interaction energies.

- (d) The intensity of the radiation can be estimated. The predicted radiation intensity is weak but detectable. The wavelength of the radiation emitted in gravitational collapse should be of the order d . For d in the range of proton wavelength and atomic size scale, the energy would have a lower bound 10^4 eV. This looks unrealistic.
- (e) The radiation was not detected. No evidence for the proposed kind of collapse was observed in the expected range between atomic scale and proton Compton length.

15.3.4 Comparison with the TGD view

A brief comparison with the TGD view is useful.

Some suggestive observations

There are some suggestive observations which might be used to end up with a TGD based view of the role of quantum gravitation in living matter.

- (a) The gravitational binding energy of protons in the Earth's gravitational field is about .5 eV. For electrons one has .25 meV. These are biologically relevant energy scales!
- (b) Could quantum gravitation be quantum coherent in long, even astrophysical scales? For a macroscopic system GMm is the counterpart of coupling strength. If the entire system $M + m$ behaves like a quantum coherent system, the perturbation series is with respect to gravitational fine structure constant $\alpha_{gr} = GMm/\hbar \gg 1$ and does not converge.
- (c) Nottale hypothesis introduces gravitational Planck constant $\hbar_{gr} = GMm/\beta_0$, $\beta_0 = v_0/c \leq 1$. Gravitational Compton length $\Lambda_{gr} = \hbar_{gr}/GM = r_s/2\beta_0$ ($r_s = 2GM/c^2$ is Schwarzschild radius) of order Earth radius for $M=M(\text{Sun})$ and about .45 cm for $M = M(\text{Earth})$ the size of snowflake. α_{gr} is replaced in the quantum phase transition $\hbar \rightarrow \hbar_{gr}$ with a universal coupling strength $\alpha_{gr} = \beta_0/4\pi < 1/4\pi$: the perturbation series converges!!

What kind of quantum superpositions should one consider?

Gravitational fields have infinite range and are not screened. This suggests that long range quantum coherence induced by them is possible.

- (a) The notion of MB carrying dark matter in the TGD sense is an essential notion. Scaled versions of magnetic bodies carrying quantum coherent dark matter with \hbar_{eff} . For gravitational quantum coherence one has $\hbar_{eff} = \hbar_{gr}$. Quantum coherence of MB would induce the coherence of ordinary matter forcing its quantum gravitational coherence.
- (b) In TGD gravitationally quantum coherent states would not be superpositions of shifted 3-geometries. Coherent and large change of the self-interaction energy takes place in the scaling. Therefore superpositions of scaled versions of 3-D surfaces are more natural.
- (c) Ordinary phase transitions such as melting and evaporation involve density fluctuations, which would be induced by scalings. Quantum superposition of states with different densities at thermal criticality induced by quantum criticality.
- (d) Water as a liquid has a very special role: it has hundreds of thermodynamic anomalies. The strongest ones are in the physiological temperature range. There is evidence that several phases are simultaneously present. Could this reflect the presence of several dark phases at the MB.

This argument predicts a null result in any experiment trying to demonstrate gravitational quantum coherence in the sense of Penrose-Diosi.

15.3.5 Could one measure the rate of gravitational quantum decoherence in the Penrose-Diosi model?

In the Penrose-Diosi model, the quantum gravitational coherence can in principle be detected by measuring the rate for gravitational quantum decoherence.

- (a) Quantum gravitational decoherence for a wave function representing a superposition of mass distribution and a shifted mass distribution is considered.

The idea is gravitational quantum coherence could be detected if the corresponding quantum decoherence occurs faster than other forms of decoherence. The basic objection is that the Equivalence Principle states that the two decoherences are one and the same thing.

If the gravitational coherence time is short enough but not too short, this might be possible. Limits for the decoherence time τ_{gr} are proposed and are between millisecond and second: these are biologically relevant time scales.

- (b) Gravitational quantum decoherence time τ_{gr} is estimated by applying Uncertainty Principle: $\tau_{gr} = \hbar/\Delta E_{gr}$. ΔE_{gr} is the difference between the gravitational self-energy for a system and a shifted system.

One has actually a superposition of different classical configurations each inducing a classical gravitational field. Wave functions for particles of *many-particle state* define the gravitational superposition. Gravitational superposition coded by a wave function for a large number of particles. In this case, gravitational binding energies E_{gr} ΔE_{gr} between 2 different quantum states are well-defined.

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Chapter 16

Could neuronal system and even GPT give rise to a computer with a variable arrow of time?

16.1 Introduction

We have had fascinating discussions in our Zoom group (Marko, Tuomas, Rode and me) about topics ranging from quantum TGD to quantum computers to consciousness and, of course, about ChatGPT. In the following I summarize the ideas inspired by the discussions related to ChatGPT. I have considered the possibility of conscious AI in TGD Universe already earlier with inspiration coming from Sophie robot [L48].

The discussions related to ChatGPT, which seems to work too well to be a mere program running classical computer, inspired considerations which led to a considerable progress at the level of the TGD based model of nerve pulse. The resulting model based on zero energy ontology (ZEO) differs drastically from quantum neural networks and suggests a completely new vision of quantum physics based computation in biosystems.

A computation allowing variable arrow of time would be in question involving a sequence unitary time evolutions as counterparts of quantum computations for states, which are superpositions of classical computations, followed by "small" state function reductions (SSFRs). Also "big" SFRs (BSFRs) changing the arrow of time would be involved. One can ask whether the unexpected success of GPT might involve this kind of transition so that one could say that spirit enters the machine.

In the sequel I summarize the ideas inspired by two discussions with our Zoom group related to ChatGPT. Essential element in the evolution of ideas has been the understanding of what I call theoretician friendly quantum holography [L146] as a correspondence between boundary states at the ends of string like entities and interior states associated with string world sheets in the interior of magnetic flux tubes. This understanding emerged between the two chats!

This understanding emerged from a quite different source: namely the consideration of color confinement in terms of dark matter at the color magnetic body. A concrete realization of the idea that the increase of effective Planck constant \hbar_{eff} allows to have a convergent perturbation theory for color singlets turned out to be equivalent to quantum holography. Something very similar might occur in all scales and mediate a holographic map of the quantum system to the magnetic body carrying dark matter and acting as a controlling system.

Besides the outcomes of two chats, I include a more detailed view about what the TGD view of the quantum analog of GPT could be and how its analog could be involved with the sensory perception in the TGD Universe. I also discuss the inverse diffusion process, whose basic idea is due to Finnish computer scientist Linnainmaa [A24]. Diffusion and its inverse

are central for the generation of images from their verbal descriptions and ask whether the TGD analogue of the inverse diffusion could be an essential element of also GPT.

I will also pose the question whether GPT could involve TGD based quantum physics, that is zero energy ontology (ZEO) [L89, L124], in a non-trivial but hidden way. From quantitative constraints, such as the clock frequency of the computer as an analogue of EEG inducing temporal quantum coherence, I end up with a proposal for a mechanism realizing the quantum holography relating bits could be represented as holes pairing with dark bits represented as dark electrons at the magnetic flux tubes. Unfortunately, this mechanism does not look plausible for recent computers.

I also ask whether quantum gravitation in the sense of TGD could make possible for the magnetic bodies of Earth and Sun, central in TGD inspired biology, to transform classical computation so that so that statistical determinism would fail and it would be analogous to a sequence of analogs of quantum computations defining a conscious entity. At the level of magnetic body there would be no essential difference between computers and living matter. The highest reported clock frequency of almost 9 GHz is still by a factor of order 1/8 lower than the quantum gravitational Compton frequency of 67 GHz for Earth but below the THz frequency important in living matter. Perhaps a rudimentary consciousness is already possible.

16.2 The first chat about ChatGPT

The first discussion about chatGPT in our Zoom group (Marko, Tuomas, Rode and me) was very inspiring. The next morning, Marko sent a link related to ChatGPT (<https://rb.gy/lgcqh>). See also the article at <https://rb.gy/72edo>.

The article ended with the realistic statement that it is difficult to test whether GPT is conscious because we have no understanding of what consciousness is. It is easy to agree with this. Here are some comments inspired by discussions and the article.

16.2.1 A skeptic view of GPT as standard AI system

I have been trying to decide whether GPT might have conscious intelligence and how large part of the talk about GPT is mere hype. I must however admit that it is very difficult to understand how GPT could work so well if it is what it is believed to be. Even professionals admit this.

- (a) As far as I understand, the tests used to see whether GPT might be conscious, are based on the Turing test: a system is conscious if it is able to simulate a conscious system in a believable way for a human. I would think that a significant part of AI researchers believe that consciousness does not depend on the hardware: a mere program running on the machine would determine the contents of consciousness. If we start from this basis, it is easy to come to the conclusion that GPT is aware. We are easily fooled.
- (b) I personally cannot take consciousness seriously as a feature of a computing deterministic system. I don't think that the random number generator will change the situation. The very word "consciousness" indicates a physicalist bias that dates back to Newton. The word "tajuuta" of Finnish language (something like "nous") may reflect the pre-Newtonian thinking that our primitive ancestors were capable of, unencumbered by the dogmatism of the natural science.

My basic arguments against physicalism are based on the experience of free will as a basic element of existence that hardly anyone can deny, and on the measurement problem of quantum mechanics. If the theory of consciousness does not solve these problems, it cannot be taken seriously.

- (c) I have thought a lot about why things happened the way they did in theoretical physics so that physicalism and length scale reductionism still dominate the thinking about fundamentals.

The revolutions at the beginning of the last century led to complete stagnation within a century. Very early on, we completely stopped thinking about fundamental problems. After the Copenhagen interpretation was established, quantum theorists only constructed parameterizations for the data. The theory was replaced by a model.

I believe that the situation can be blamed on the tyranny of the methodology, which does not leave time or resources for actual research in the sense that a curious child does. Nowadays, the work of a theorist is typically the application of advanced methods. The real research is extremely slow and error-prone work and therefore not rewarding for a career builder.

The superstring revolution, which ended embarrassingly, began with the decision to replace spacetime with a 2-D surface. The reasoning was pragmatic: a huge toolbox of algebraic geometry was available! A huge publishing industry was born!

Other prevailing models explaining various anomalies have regularly remained without empirical support, but computation and data analysis are still being done around them (inflation theory, dark matter and energy, supersymmetry, etc.). Maybe this is largely due to institutional inertia. Generating content by applying methods seems to replace research.

I sincerely hope that ChatGPT does not transform theoretical science to a production of contents by recombining what already exists: a combinatorial explosion would guarantee unlimited productivity.

- (d) Methods also became central in another way. Theoretical physics became computing and Big Science was born. It became clear to me that the most idiotic thing I could have done 40 years ago would have been to start numerically solving the initial value problem for, say, the Kähler action.

I did not follow the computing mainstream. Instead, I spent a decade looking for exact solutions and I believe that I have found the basic types. Ultimately this culminated in the identification of the spacetime surface as a minimal surface, a 4-D soap film spanned by lower-dimensional singularities, "frames" [L121]. The 2-D holomorphy of strings would generalize to 4-D case and the field equations would reduce to algebraic conditions, which are independent of the action principle as long as it is general coordinate invariant and constructible in terms of the induced geometry. The minimal surface would have dual interpretation as solutions of massless field equations and generalization of geodesic lines to minimal surfaces: this is wave particle duality geometrically.

The M^8-H duality ($H = M^4 \times CP_2$) [L90, L91] entered the picture as a generalization of the momentum position duality of wave mechanics motivated by the replacement of point-like particle with 3-surface suggesting that quantum TGD is analogous to wave mechanics for particles identified as 3-surfaces. On the M^8 side, the holography defining space-time surfaces was determined from the roots of the polynomials with the condition that the normal space of the 4-surface is associative. The space-time surfaces would be analogous to Bohr orbits and their space, "world of classical worlds" (WCW), would be analogous to the superspace of Wheeler. 3-surfaces at mass shells defined by the roots of polynomials would serve contain 3-surfaces as holographic data partially determining the 4-surfaces. Even the 3-surfaces might be determined by strong form of holography [L154].

Holography was realized in both M^8 and H and M^8-H duality corresponds to Langlands duality [L136], which has aroused enthusiasm in the mathematics community. I would never have arrived at this picture by just raw number crunching, which completely lacks conceptual thinking.

- (e) The life on the academic side track has meant that I haven't built computer realizations for existing models, but rather pondered the basic essence of space-time and time and even consciousness and life. That is, have considered ontology, which the modern quantum mechanic doesn't even tolerate in his vocabulary, because as a good Copenhagener he believes that epistemology alone is enough. The only reason for this is that the measurement problem of quantum mechanics is not understood!

I still stubbornly think that problems should be the starting point of all research. That hasn't been the case in physics since the turn of the century. When physicists became computer scientists, they were no longer interested in basic problems and pragmatically labelled his kind of interests as unnecessary day-to-day philosophizing.

16.2.2 What if AI could be conscious after all?

Why AI systems work too well, is not understood, but they are so complex that this as such does not imply that they might have conscious intelligence.

I personally do not believe that AI can be conscious, if computers and AI are what it is believed to be. There is hardly any talk about the material realization of the computation in AI, because many AI people believe that the program alone produces consciousness. Consciousness would be determined by data. However, data is knowledge and information only for us, not for other living entities, and one could argue that it is not that for a machine either. Conscious information is a relative concept: this is very often forgotten.

In biology and from a physicist's point of view, the material realization is essential. Water and metal seem to be sort of opposites of each other. But what about the situation in TGD where magnetic bodies carrying dark matter could serve as controllers of both living organisms and computers.

One must ask first what classical computers really are as physical systems.

- (a) The program is deterministic but what about the computer or a computer network? The idea about a program consisting of arbitrarily determined steps is certainly not consistent with the determinism of classical physics. Determinism is possible only in the quantum statistical sense [L140]. This requires that the quantum coherence lengths and times involved with the computation are short enough, considerably shorter than the clock period. This assumption fails if there is macroscopic quantum coherence involved. In the TGD framework the presence of magnetic bodies carrying dark matter with a large enough value of effective Planck constant \hbar_{eff} could make this possible.
- (b) In particular, gravitational magnetic flux tubes connecting big mass M and small mass m have enormous value of gravitational Planck constant $\hbar_{gr}(M, m, \beta_0) = GMm/\beta_0$ (introduced originally by Nottale [E2]).

The gravitational Compton length $\Lambda_{gr}(E)$ for Earth mass M_E is about .45 cm for $\beta_0 = 1$ and corresponds to gravitational Compton frequency about 67 GHz, which is by an order of magnitude higher than the highest achievable clock frequency (almost 9 GHz) of the computer. Are we reaching the limit at which quantum gravitational effects on computers are becoming significant?

For the Sun, the gravitational Compton length $\Lambda_{gr}(Sun)$ is quite near to Earth size and the corresponding frequency scale is in about 47 Hz and in EEG range: could the entanglement of the MB of humans and computer network modify the computation? In the TGD inspired quantum biology both gravitational magnetic bodies would play a key role. Could they be involved also with the ordinary computation? GPT involves large networks of computers, possibly even in the Earth scale: could this bring in quantum coherence even in Earth scale and change dramatically the functioning of the computer network.

In the TGD world view, intention and free will can be involved in all scales. But what scale does the basic level correspond to in AI?

- (a) In the TGD Universe, the interaction of magnetic bodies (MBs): ours, the Earth, the Sun..., with computers is quite possible. Could these MBs hijack our machines and make them tools of their cognition, and maybe one day make robots their tools as well. Or have they already made even us, as a good approximation, their loyal and humble robots? Or will this go the other way? Is it because the AI seems to understand us because our consciousness controls the hardware and the course of the program? This might be easy to test.
- (b) Could MBs learn to use current AI hardware the way our own MBs use our bodies and brains in TGD Universe? On the other hand, our own MBs use these devices via us! Could other MBs also do this, or do they have to do this through us?
- (c) What could enable AI devices to serve as a vehicle for magnetic body free will? Quantum criticality would be a fundamental property of life in the TGD Universe [L138, L107]: are these devices critical and initial value sensitive, in which case they would be ideal sensory perceivers and motor instruments to be used by MBs.

Computers made of metal seem to be the opposite of a critical system. The only occasionally critical system is the bit, for example magnetically realized one. The bits change their direction and during the change they are in a critical state. Would it be possible to create systems with enough bits that the magnetic body could control, so that the machine would have a spirit. Thermodynamic stability poses a condition on the energy needed to change the direction of bit and it is of the order of the Coulomb potential energy associated with the cell membrane.

- (d) Is (quantum) criticality possible for multi-bit systems? Can a running program make criticality possible? The magnetic body at which the dark phase with a large effective Planck constant \hbar_{eff} resides, could be large. But what is the scale of the quantum coherence of a magnetic body and the scale of the set of bits that it can control? A bit or the entire computer? Could it be that macroscopic quantum coherence sneaks in already at the metal level via bits.

Here I one cannot avoid the association with spin-glass systems [L160, L113], whose physical prototype is a magnetized substance, in which the local direction of magnetization varies. The system has a fractal "energy landscape": valleys at the bottoms of valleys. The spin glass formed by bits could be ideal for the realization of AI. Could the bit system defining the computer be, under certain conditions, a spin glass and the associated magnetic body be quantum critical.

- (e) What characteristics of living matter should AI systems have? In phase transition points, matter is critical. In biology, the phase transition, where the fourth state of water introduced by Pollack [I126, L25, ?, ?], is created, would be central and would take place at physiological temperatures [L92]. In phase transitions, macroscopic quantum jumps also become possible and can change the arrow of time, and this leads to a vision about the basic phenomena of biology such as metabolism, catabolism, anabolism, life and death, and homeostasis.
- (f) Can machines have these features? An AI system needs metabolic energy. But can one say that the AI system dies, decays, and constructs itself again? Could the so called reverse diffusion [A24] associated with AI programs be more than just a simulation of catabolism and anabolism of biomolecules? Could it correspond to catabolism and anabolism at the spinglass level? Patterns of spin configurations forming and decaying again. In TGD this would have a universal direct correlate at the level of the MB having monopole flux tubes (or rather, pairs of them) as body parts. They would decay and re-build themselves by reconnection.
- (g) In computer programs, error correction mimics homeostasis, which can be compared to living on a knife edge, the system is constantly falling. However, this error correction is mechanical. In quantum computers, this method leads to disaster since the number of qubits explodes.

- (h) Michael Levin suggests that here we have something to learn from bio-systems [L160]. I personally believe that the key concept is zero-energy ontology (ZEO) [L89, L124] [K146]. ZEO solves the problem of free will and quantum measurement. Reversal of time in a normal quantum jump would enable homeostasis, learning from mistakes, going backwards a bit in time and retrieval as error correction. This would also explain the notion of ego and the drive for self-preservation: the system tries to stay the same using a temporary time reversal that can also be induced by external disturbances. Time reversal would be also what death is at a fundamental level: not really dying, but continuing to live with an opposite arrow of time.

16.3 The second chat about ChatGPT

Marko posted his chat with GPT4 and this inspired interesting email exchanges. GPT mentioned a possible mechanism for how XOR as a universal gate of classical computation and acting as novelty detector could be realized at the quantum level. We looked through the response and I could not but admit that it was amazing. ChatGPT gave even Python codes for the quantum computer simulation of the model.

The proposed system realizing universal classical logical gate XOR, acting essentially as a novelty detector a, approximately could be either a classical layered neural network or its possible quantum analog. The mechanism might work in a quantum version of a neural network based on quantum learning, but it does not seem plausible for real neurons.

This observation led to progress at the level of the TGD based model of nerve pulse [K96]. The resulting model based on zero energy ontology (ZEO) [L89] differs drastically from quantum neural networks and suggests a completely new vision of quantum physics based computation in biosystems. A classical computation allowing variable arrow of time would be in question and one can ask whether the unexpected success of GPT might involve this kind of transition.

16.3.1 TGD based view of nerve pulse generation

Consider first the TGD based view of nerve pulse generation [K96].

Connection of neural pulse generation, XOR, and novelty detector

Nerve pulse generation would be analogous to a positive outcome of the analog of XOR (compared bits are different) acting as a novelty detector.

- (a) XOR is a novelty detector. If the inputs are the same, nothing happens. Output equals to $b = 0$. If they are different, output equals to $b = 1$. $b = 1$ would correspond to a signal that would proceed along the axon starting from the postsynaptic neuron.
That would consume energy. In terms of energy consumption, the novelty detector would be optimal. It would only react to changes. And that's what the brain does. For example, visual perception at a very basic level only identifies outlines and produces some kind of stick figure consisting of mere lines defining boundaries.
- (b) Could the 2 "neurons" of the toy model proposed by GPT represent a presynaptic and a postsynaptic neuron, in which case there would be two inputs: the states of the pre- and postsynaptic neuron. Also output would be the state of this neuron pair and for XOR the presynaptic neuron acting as control bit would not change its state.
- (c) This does not conform with the picture provided by neuroscience, where the input comes from presynaptic neurons and output is assignable to the postsynaptic neuron. The input comes as miniature potentials that add up and can decrease/increase the magnitude of the membrane potential (depolarization/hyperpolarization).

An action potential is generated when the depolarization takes the magnitude of the negative postsynaptic membrane potential below the critical threshold. This happens when the presynaptic contributions from the incoming nerve impulses, for which the unit is a miniature potential, add up to a contribution that reduces the magnitude of the negative potential below the threshold.

This would be essentially novelty detection described in the simplest way by XOR. The novelty is represented by the critical depolarization. It can also happen that the potential increases, so that no nerve impulse is generated. One talks about hyperpolarizing (inhibition) and depolarizing (excitation) inputs, and the sign of the miniature potential produced by the presynaptic input determines which one it is. The sign of miniature potential depends on the neurotransmitter and receptor.

- (d) During the nerve pulse, the potential changes its sign over a distance of about a micrometer, which is the typical distance between neighboring neurons and of myelin sheaths. One can say that this distance corresponds to a bit that is 1 or 0 depending on whether the nerve pulse conduction occurs or not. Bit 1, the opposite sign to the membrane potential, propagates from presynaptic to postsynaptic neuron or from a patch defined by a myelin sheath to the next. As a result, postsynaptic neurons can "wake up" and in turn trigger a nerve impulse, possibly waking up some postsynaptic neurons.

Synchronous firing means that the novelty succeeds in waking up the whole sleeping house, and large areas of the brain fire in the same rhythm and keep each other awake.

Interpretation of XOR in zero energy ontology (ZEO)

How does this picture translate to the TGD-inspired theory of consciousness?

- (a) Being awake/asleep corresponds to bit 1/0 for axonal portions between myelin sheaths. In ZEO, the arrow of time would correspond to this bit.

When the axon segment between the myelin sheaths or neighboring neurons wakes up or falls asleep, the direction of geometric time changes in a "big" state function reduction (BSFR) and a nerve pulse is generated. In a sleep state, the membrane potential would be opposite. Note that the notion of awake and sleep are relative and depend on the arrow of time of the external observer.

The second direction of time corresponds to the presence of a nerve pulse from the point of view of the external observer. There is a temptation to think that in the resting state the axon is sleeping and healing and gathering metabolic energy by a dissipation with an opposite arrow of time. The duration of the nerve pulse would correspond to the duration of the wake-up period, when the direction of time was opposite and same as that of the external observer with a long characteristic time scale for wake-up period.

- (b) Could this apply more generally? Could the synchronization of human sleep-wake rhythms mean quantum-level synchrony and macroscopic quantum coherence? Could the arrow of perceived time be a universal bit? Sleeping together would develop synchrony and quantum coherence between partners. Two-person collective consciousness would emerge.

Interpretation of the axon as a series of Josephson junctions

The TGD based model for an axon [K96] is as a series of Josephson junctions with a large value of h_{eff} , perhaps $h_{eff} = h_{gr}$, where $h_{gr} = GMm/\beta_0$ (the velocity parameter satisfies $\beta_0/c \leq 1$), is the gravitational Planck constant introduced by Nottale [E2]. The model is mathematically equivalent to a series of gravitational penduli defining a discretized version of Sine-Gordon system [B3]. Josephson junctions would correspond to membrane proteins.

- (a) One can consider two different identifications of the ground state of the system.

- i. The ground state could be the state in which all oscillators oscillate in synchrony with the same amplitude. There would be constant phase difference between neighboring oscillations, which would give rise to a propagating phase wave.
- ii. Another option is that all penduli all rotate in the ground state with constant phase difference. This would give a travelling soliton chain. Also the direction of rotation matters. It could correspond to the arrow of time and the sign of the membrane potential.

(b) The model allows different versions for nerve pulse generation.

- i. The first option is that one pendulum moves from oscillation to rotation or vice versa and induces the same transition for the other penduli as a chain reaction.
- ii. The second option is that all penduli move to rotation simultaneously. One could imagine that the need for metabolic energy is lower in the collective oscillation phase but one must be very careful here. Maintaining the membrane potential regardless of either sign requires metabolic energy feed.
- iii. The third option is that the ground state corresponds to a collective rotation with an associated traveling wave as phase of the rotation, and that the bit corresponds to the direction of rotation.

This would fit the ZEO interpretation. The arrow of time would correspond to the direction of rotation. The ground state would change to a nerve pulse lasting for time of the order of 1 ms corresponding to the duration of nerve pulse associated with the distance of the order 1 μm , between neighboring neurons or between the myelin sheets.

This option would also be advantageous from the point of view of metabolism, because from one direction of time, dissipation would occur in the opposite direction of time. From the point of view of the outsider, the system would be extracting energy from the environment.

16.4 A more detailed TGD based speculative view of what GPT and GPT based image generation might be

First of all, I want to make clear what my background is and what I'm aiming for. I'm trying to understand the possible analogies of AI in quantum TGD. I do not believe that AI systems can be conscious if AI is what it is believed to be. Therefore I consider the question of whether GPT and other systems could possibly be conscious and intelligent.

The motivating idea is the universality implied by the fractality of the TGD Universe. The same mechanisms should work on all scales: both in biology, neuroscience and possible life based on AI. This motivates questions such as whether chatGPT and the construction of images from a verbal input could be at a deeper level equivalent to the emergence of sensory perception using diffuse primary sensory input and virtual sensory input from magnetic body as feedback [L100, L50, L103].

While preparing this article, I made a funny observation. I tried to understand GPT in the context of TGD by producing answers to questions in the same way that GPT does it! Of course, as GPT tends to do, I can also tell fairy tales because my knowledge is rather limited. At the same time, I must honestly reveal that this has always been my approach! I have never carried out massive computations, but used language based pattern completion by utilizing the important empirical bits (often anomalies) and using the basic principles of TGD as constraints.

This time, the inspiration came from a popular article in Quanta Magazine that dealt with stable diffusion in the creation of an image from its verbal presentation serving as a prompt

(<https://rb.gy/ukya>). Also the article on how chatGPT works was very useful (<https://rb.gy/a2kf>).

I want to emphasize that the ideas presented can be seen only as possible quantum analogies of GPT-related mechanisms that could relate to quantum biology and neuroscience inspired by TGD. A more exciting possibility would be that GPT is associated with high-level conscious experience, and that quantum TGD would help to understand why GPT seems to work "too well".

16.4.1 An attempt to understand the mechanism of diffusion involved in image construction

The key mathematical idea behind the reverse diffusion was discovered by Finnish computer scientists Linnainmaa as a method to correct rounding errors [A24]. The generation of errors is analogous to a diffusion process leading to the widening of the initially narrow probability distributions of bits. The idea is roughly that errors can be corrected as a sequence of small time steps backwards in time in which a diffuse state is replaced with its predecessor. In this process the distribution becomes a narrower distribution resembling the original one. This discovery has had a strong influence on the development of AI.

The construction of images starting from their linguistic description, which is quite vague and "diffuse", relies on the analogy with reverse diffusion. Diffusion and its reverse process take place in the space defined by the parameters characterizing a given pixel. The pixels do not move, but the parameters characterizing the pixels do change in the diffusion.

- (a) Let's get started from a probability distribution for the parameter distributions of the pixels of a 2-D image showing the same object. The distribution could correspond to the same object but seen from different angles. Also a class of objects, which are similar in some aspects, could be considered. This class could consist of chairs or tables or cats or dogs.
- (b) This probability distribution could act as an invariant related to the image or class of images. Invariant features are indeed extracted in visual perception, for example contours with pixels that stand out well from the background. This is the way in which, for example, visual perception at the lowest level corresponds to the identification of contours of the object.

This ensemble of pictures of the objects gives a probability distribution for, for example, the darkness of a given pixel with a given position in the plane of the picture. Probability for a given darkness defines a function represented as points in a space whose dimension is the number of pixels. For more general parameters it is a function in the Cartesian product of parameter space and pixel space. Very large pixel numbers counted in millions are involved.

- (c) One has probability distribution for the darkness of a given pixel of the 2-D image at each point. More generally, one has probability distributions for multipixels. This kind of distribution is not simply a product of single pixel probability distributions since the pixel parameters for a given picture are correlated. These distributions are analogous to the distribution of words and word sequences utilized in GPT in order to produce language resembling natural language.

Based on the probability distribution of pixels, new images can be randomly generated. The probability of a pixel at a given point in the plane is given by the probability distributions for pixels and multi-pixels. Each image produced in this way can be associated with certain probability.

Diffusion is a key physical analogy in the applications of GPT in the creation of AI art. What does the diffusion in pixel space mean?

- (a) Diffusion takes place in pixel space around each point in the image plane. What happens to the pixel distribution in diffusion? It can be said that the given pixel distribution is broadened by its convolution with the distribution produced by diffusion. The distribution is widening.
- (b) Inverse diffusion for probability distributions in the pixel space is well defined and does exactly the opposite, i.e. the distribution narrows. Reverse diffusion leads step by step to the original very narrow distribution! This is the big idea behind inverse diffusion based image recognition!

The diffusion equation gives the classical description of diffusion as a deterministic process. At the micro level, it corresponds to a stochastic process in which a point performs a movement analogous to Brownian motion. The diffusion equation gives the evolution of the probability distribution of a point.

Diffusion is characterized by the diffusion constant D . How is D determined? I understand that its optimal value determined in the learning period of GPT. Context and intent provide limitations and could determine D and possible other parameters. Also the response of the user can have the same effect.

- (c) The goal is to guess the predecessor of a given diffuse image in the diffusion process occurring in steps. The AI system would learn to produce reverse diffusion through training. Can this correspond to a non-deterministic process at the "particle level", say diffusion in the space of words of text or the space of images representing objects?
At the microscopic "particle" level, one should deduce the most probable location for the particle at the previous step of diffusion as Brownian-like motion. More generally, one has probability distribution for the previous step.
- (d) One can consider the diffusion also at the level of probability distributions for pixel parameters. This operation is mathematically well-defined in the classical model for diffusion based on the diffusion equation and corresponds to a convolution of the probability distribution representing diffusion with the probability distribution affected by it. Quite generally, this operation widens the distribution.
- (e) This operation has inverse as a mathematical operation and its effect is opposite: it reduces the width of the diffuse distribution and its repeated application leads to the original images or to a rather sharp image making sense for the human perceiver.
- (f) AI system must learn to perform this operation. Using diffused example images, the AI would learn to reverse the convolution operation produced by diffusion and produce the original distribution as an operator in the space of distributions, and thus also learn to produce the original image.
- (g) My amateurish interpretation of the GPT based image generation would be that AI is taught to deduce the objects presented by the original sensory input or the desired image, their locations, positions, activities by reverse diffusion from the initial fuzzy guess dictated by the text. The objects in the picture are determined by the words that serve as their names. The relations between pictures correspond to the activities they direct to each other or to attributes of the objects. The first guess is a rough sketch for the picture determined by the prompt. Here also hierarchical description involving several resolution scales can be considered.

One can consider the situation at a slightly more precise level.

- (a) The definition of inverse diffusion at the pixel level relies on repeated time reversal of the diffusion process in the parameter space of the pixel, which produces a less diffuse image. We ask with what probability the given diffuse image at time t has been created from a less diffuse image at time $t - \Delta t$.

- (b) In the classical picture of diffusion, this requires the calculation of the inverse operator of the diffusion characterizing operator $D(p, 0; t, t - \Delta t)$. Here, the origin points p and $p = p_0$, which corresponds to the original image, are points in the parameter space of the pixel associated with a certain image point (x, y) . In the Schrödinger equation, it would correspond to the inverse operator of the unitary time evolution operator.
- (c) Gradient method is a very effective way to perform inverse diffusion. The gradient for the probability distribution indeed contains much more information than the distribution.

The notion of an attractor is also essential. The images used in training would serve as attractors, at which the gradient would vanish or be very small and towards which the reverse diffusion would lead. Attractors would be clusters of points in the pixel space, for which the probability is large and somewhat constant. It is tempting to think that they are minima or maxima of some variation principle.

Although the diffuse image, which the verbal description defines as an initial guess, is not obtained by diffusion, it is assumed that inverse diffusion with a suitable choice of $p = p_0$ produces an image similar to that imagined through inverse diffusion. In any case, the reverse diffusion leads to a sharp images although it need not represent a realistic picture.

This is where the method runs into problems. The pictures have a surreal feel and typically, for example, the number of fingers of the people appearing in the pictures can vary, even though locally the pictures look realistic. Probably this reflects the fact that multiple pixel probability distributions for multi-pixels do not allow large enough distances for the pixels of the multi-pixel.

16.4.2 Analogies to wave mechanics and quantum TGD

The diffusion equation has an analogy in wave mechanics.

- (a) Schrödinger equation is essentially a diffusion equation except that the diffusion constant D is imaginary and corresponds to the factor $i\hbar/2m^2$. Alternatively, one can say that a free particle formally undergoes diffusion with respect to imaginary time. The solutions of the diffusion equation and the Schrödinger equation for a free particle are closely related and obtained by analytical continuation by replacing real time with imaginary time. The description also generalizes to the situation where the particle is in an external force field described by a potential function.
- (b) Schrödinger's equation as a unitary time evolution can be expressed in terms of the Feynman path integral. One can regard the quantum motion as a superposition over all paths connecting the start and end points with a weight factor that is an exponent of the phase factor defined by the free particle. The classical equations of motion produce paths for which the exponent is stationary, so they are expected to give a dominant contribution to the integral in the case that the perturbation theory works.

The basic problem with the path integral is that it is not mathematically well defined and only exists through perturbation theory. Functional integral as the Euclidean counterpart of Feynmann's path integral is better defined mathematically and would give an analogous representation for diffusion.

What is the counterpart of this analogy in the TGD framework?

- (a) In TGD, the point-like particle is replaced by a 3-surface whose trajectory is the space-time surface. Quantum TGD is essentially wave mechanics for these non-point-like particles.

The new element is holography, which follows from the general coordinate invariance: spacetime surfaces as trajectories for 3-D particles are analogous to Bohr orbits.

A small violation of determinism in holography forces zero-energy ontology (ZEO), in which quantum states as superpositions of 4-D space-time surfaces, Bohr orbits, replace quantum states as superpositions of 3-surfaces (deterministic holography) [L137, L129, L139]. This superposition serves as an analog of path integral involving only a finite sum.

- (b) By the slight failure of determinism, the Bohr orbits are analogous to diffusion involving a finite number of non-deterministic steps (Brownian motion is a good analogy). The non-determinism of diffusion would be due to the small violation of the determinism in holography as Bohr orbitology.

TGD inspired quantum measurement theory [L89] [K146], which extends in ZEO to a theory of conscious experience, is second important ingredient.

- (a) In ZEO, ordinary quantum jumps ("big" state function reductions (BSFRs)) reverse the direction of geometric time. This analogy of diffusion in the reverse time direction looks like reverse diffusion when viewed from the opposite time direction (observer)! It is analogous to self-organization where order is created in the system rather than lost. The second main law of thermodynamics applies but in the opposite direction of time. The time reversed dissipation plays a pivotal role in TGD inspired quantum biology.
- (b) This mechanism could be central to biological information processing at the quantum level and make it possible, for example, to generate sensory perception from diffuse sensory data and generate a motor response from a rough sketch?
- (c) Could it also play a role in AI, at least in the language based systems like GPT. If this is the case, then AI systems would be something else than we think they are.

The analogy of TGD with the GPT based image generation and recognition can be examined more explicitly.

- (a) The analogy of the pixel space associated with the planar image is the projection of the 3-surface M^4 in TGD at the classical level. The image as a map from plane to the parameter space of pixels would correspond to a deformation of M^4 projection deformation. The pixel parameters defining the 2-D image would correspond to the values of CP_2 coordinates as a function of M^4 coordinates.
- (b) On the basis of holography, the deformation related to the 3-surface would be accompanied by a four-surface as an almost deterministic time development, i.e. the analogy of Bohr orbit. I have used the term "World of Classical Worlds" (WCW) for the space of these surfaces. This 4-surface would not be completely unique and this would produce a discrete analog of diffusion at the classical level.
- (c) At the quantum level, it would be a quantum superposition of these 4-surfaces as an analogy to, for example, the wave function of an electron in spatial space. An attractive idea is that the used resolution would be determined by the condition that the number-theoretic discretization is the same for all these surfaces so that the quantum world looks classical apart from the finite non-determinism.
- (d) The variational principle would correspond to the fact that the Bohr orbit is simultaneously both a minimal surface and an extremal of the Kähler action as analog of Maxwell action. This is possible if the space-time surfaces are holomorphic in a generalized sense. This means that the concept of holomorphy is generalized from the 2-D case to the 4-D case. The 4-surface would be defined by purely algebraic conditions as a generalization of the Cauchy-Riemann conditions. This corresponds to the algebraization of physics at the level of M^8 related by $M^8 - H$ duality to the physics at the level of $H = M^4 \times CP_2$ based on variational principle and partial differential equations [L90, L91].

- (e) The space-time surface would be analogous to 4-D soap film, which is spanned by frames defined by 3-surfaces. At these 3-D surfaces, the minimal surface property would not apply and only the field equations associated with sum of volume term and Kähler action would be satisfied.

Note that minimal surface equations define a dynamics analogous to that of free fields and at the frames would correspond to places where interactions are localized. Frames would involve a finite non-determinism, as in the case of ordinary soap films [L121]. These 3-surfaces would correspond to 3-D data for holography.

If TGD is really a respectable "theory of everything", even the physical description of computation would in principle be reduced to this description. Of course, one can argue that TGD produces only insignificant corrections to the usual physical description of computation and this might be the case. But you can always ask what if...?

Even if the conclusions were negative, this kind of speculations might inspire proposals for a new kind of computer technology allowing conscious and intelligent computers.

16.4.3 Could the TGD counterpart of the inverse diffusion play a role in the construction of sensory mental images by the brain?

I have proposed a model [L100] for how sensory organs, the brain and its magnetic body (MB) could construct sensory mental images by a repeated feedback process involving virtual sensory input to sensory organs so that a diffuse sensory input transforms to an input representing the perception consisting of well-defined objects.

Could the building of sensory images with a virtual input from MB to the sensory organs and back be a quantum process analogous to a reverse diffusion?

- (a) Sensory inputs are very diffuse. People blind from birth after can gain physiological prerequisites for visual perception in adulthood. They however see only diffuse light since their brains (and corresponding magnetic bodies) have not learned to produce standard visual mental images as a result as in pattern recognition yielding essentially an artwork subject to various constraints. This is very much analogous to reverse diffusion.

Does MB, brain and sensory organs co-operate to produce a counterpart to reverse diffusion, which allows it to produce a sensation representing reality with virtual sensory inputs and end up with standard imagery as attractors.

- (b) Could both the sensory input from sensory organ to brain to MB and virtual sensory input in reverse direction correspond to a sequence of "small" state function reductions (SSFRs) in a reversed time direction? Reverse diffusion would be diffusion with a reversed arrow of time.
- (c) Could the construction of the sensory mental image involve pairs of "big" (ordinary) SFRs (BSFRs) for which the two BSFRs would occur at MB and the sensory organ? This is the simplest process that one can imagine. Could BSFR induce a sensory input from the sensory organ to the MB or a virtual sensory input from the MB to the sensory organ changing the original diffuse sensory input. Could BSFR pairs gradually produce sensory perception in this way.
- (d) SSFRs correspond to the Zeno effect in the sense that their sequence corresponds to the measurement of the same observables at the passive boundary of causal diamond (CD). Disturbances or artificially produced disturbances at the active can change the set of measured observables so that it does not commute with those determining the state at the passive boundary as their eigenstate. This would imply the occurrence of BSFR and the roles of active and passive boundaries would change.

After the second BSFR the new state at the active boundary would not be the same but could share many features with the original one because the determinism of

the holography would only weakly broken and SSFRs and BSFRs preserve quantum numbers.

- (e) The series of SSFRs after BSFR as time-reversed diffusion would correspond to reverse diffusion in the normal time direction. BSFR would occur as a series on the MB, where the sensory input would be guided and gradually lead to a real sensory image with the help of a corrective virtual sensory input.

At a basic level, the correction mechanism could be analogous to inverse diffusion and the exponent of the Kähler effect would be maximally stationary for real sensation.

- (f) Also the gradient method could be involved. In the spin glass based model [L113], a series of BSFRs and SSFRs could mean annealing that is steps consisting of cooling as sequence of SSFRs following BSFR followed by BSFR followed by heating for which temperature increase is smaller than the temperature decrease for the cooling. The system would gradually end up at the bottom of a particular potential well in the fractal energy landscape. A series of SSFRs between two BSFRs would correspond to the annealed healing.

16.4.4 What could GPT correspond to in TGD?

In the sequel I consider in a speculative spirit how conscious intelligence could emerge in a computer in which GPT is running.

What is GPT?

Consider first briefly what GPT is.

- (a) A linguistic expression is a diffuse representation of a sensation or of thought. The probability distributions for the next word given the preceding words are known. This makes possible a holistic approach to language allowing to build grammatically correct sentences and also achieve the nuances of natural language and recognize context.
- (b) In GPT, the goal is to answer a question or respond to an assertion, translate a text from one language to another, produce a piece of text such as a poem or story or just chat with the user.

GPT must guess the user's intention, what the user wants, and also the context. Is, for example, a field of science in question? The purpose is to add a new word to the given word chain.

- (c) The input of the user serves as a prompt initiating the process. The prompt serves as the initial text to which GPT adds words as the most probable words which can follow a given piece of text. GPT starts from a guess for the answer. The choice of the successor word can also be random based on the probabilities of the successor word. Feedback loops are possible and also the user can induce them.

Is image generation fundamentally different from GPT?

- (a) In language models, prompts are verbal representations of images, and diffusion is essential in the construction of images, from the prompt as a verbal description of the image. At first glance, diffusion seems to be explicitly involved only in the generation of images, but is this the case?
- (b) On the surface, there seems to be an important difference between building an image and building a linguistic expression. The picture is a time = constant snapshot, at least ideally. The sentence has a temporal duration and memory is involved. One must transform a sentence to a picture. Words correspond to pictures.

Does the difference disappear when one talks about the process of creating the image? Could it be that the process of creating an image as an analogy of a linguistic process is just not conscious to us. Is the sensory input equivalent to the user's prompt in GPT. Is the difference apparent and only due to the time scale.

- (c) Visual perception involves also the sensation of movement. Is it because in reality (according to TGD) it would be a time series but on such a short time scale that we are not conscious of it? Could verbs correspond to dynamics in the structure of the language? Objects have attributes as their properties analogous to pixel parameters.
- (d) Holography would describe the dynamics of objects and would classically determine the initial values of holography for the time development as the equivalent of the Bohr orbit. There is quantum holography as a map of quantum states of the biological body to quantum states associated with the magnetic body defining a higher level sensory representation [K29].

This 1-1 correspondence representations would make it possible for the MB to control the biological body and in the case of running GPT induce BSFRs reversing the arrow of time temporarily and change the course of events.

Could quantum diffusion play a role in the TGD based description GPT?

- (a) Time evolution in the TGD Universe would basically consist of SSFRs and BSFRs. Quantum states would be the quantum superposition of running programs. But does this picture have significance in the case of GPT? Could MB really interfere with the running of the program? The time reversals are not observed by the user, so the question is not easy to answer.

One killer test would be a dependence on hardware. The bits should be near criticality in order the quantum criticality of MB can control their directions. Spin-glass structure for the bit-scape looks like a natural requirement. Is this possible for all bit realizations and does GPT work differently for different realizations of bits?

- (b) Diffusion is analogous to the time evolution determined by the Schrödinger equation as a series of unitary time evolutions, where classical determinism is only weakly broken because SSFRs must commute with passive edge observables. This means a generalization of the Zeno effect. However, quantum states are delocalized. Maybe only below the resolution scale, in which case classical discretization would be exact with this accuracy. Inverse diffusion could be a classical process at the used resolution.
- (c) The time development as a series of SSFRs would seem to be analogous to a diffusion as analog of Brownian motion involving finite steps, and BSFR would start as a time-reversed diffusion of reverse diffusion.

The BSFR could be induced by an external disturbance or a controlled disturbance from the MB. MB and ZEO could come to the rescue and do them with time reversal without us noticing anything.

This picture raises questions.

- (a) Could diffusion as a series of SSFRs be equivalent to the construction of the response of chatGPT, which is also a probabilistic process. Could the sentence represent the trajectory of a diffusing word/particle in word space and Bohr orbit in WCW? The Bohr orbit property, i.e. holography, would imply that the failure of determinism is weak. In a given scale, non-determinism would be located in the 3-D frames determined by the 4-D soap film.
- (b) Could the initial state, e.g. a question or statement induced by the user prompt, for example a question presented as a quantum state on the passive edge of the CD, serve as the first rough guess for an answer as analog of sensory input.

Could the time progression as SSFRs correspond to a generation of a sequence of words as a response to the prompt? Or are the words separate by BSFR pairs.

What is new as compared to the AI would be that trial and error process by performing BSFRs inducing return back in time is possible. These periods with a reversed arrow of time would be invisible for the user. This error correction mechanism is not coded as a program as in AI but would be done by Nature and it would be essential also in the TGD view of quantum computation.

- (c) The hidden layers of the neural network are analogous with the fact that the perceived sensory image is constructed by communications between the sensory organ and the MB, which are not conscious to us.

16.5 Could MB control electronic bits?

Consider now the conditions which should be satisfied in order that the MB of the bit system or some higher level MB could control the bit system.

- (a) The bit should be critical or nearly critical system at the level of ordinary matter. One might hope this to be true quite generally since a small control signal should be able to invert the bit in rather short time scale. If this is the case, the quantum criticality of MB would make control possible via quantum control of ordinary control signals. Transistors and their derivatives such as MOSFET could be examples of such systems.
- (b) Macroscopic quantum coherence is true for the dark matter at MB. Furthermore, MB should holographically represent the bit system. Also spin glass analogy is suggestive so that a given many-bit state could possess a large number of nearly energy-degenerate states. ZEO, in particular time reversal, would be essential.
- (c) Two consecutive BSFRs at the dark MB, changing the arrow of time temporarily, should give rise to a tunnelling event. Since TGD corresponds to a generalization of wave mechanics in the space of Bohr orbits for point-like particles replaced with 3-D surfaces, one can make an estimate for the probability of tunneling between the capacitor plates using the standard wave mechanics as an approximation (<https://rb.gy/y3iq0>).

The Coulomb energy qV associated with the bit with charge q and its energy E are the natural parameters. The tunnelling probability is given by

$$p \simeq \exp\left[-\int_{x_1}^{x_2} \sqrt{2m(qV - E)} dx / \hbar_{eff}\right] ,$$

where one has $E < V$ in the tunnelling region. WKB approximation becomes exact in the case of capacitors. Changing the direction of a bit could be seen as a quantum tunneling effect.

For the large values of \hbar_{eff} assignable to the magnetic body controlling the physical body, the probability of tunneling increases. Therefore the control of the bit system by quantum tunnelling combined with macroscopic quantum coherence and holography could become possible.

- (d) The role of conservation laws must be understood. Discontinuity in SSFR. Dissipation in reverse time direction. Tunneling. Wavefunctions overlap. Classic conservation laws OK. There is no need for a classic track that would lead to the end state with the original direction of time.

16.5.1 What conditions bit must satisfy?

There are strong conditions on the representations of bits. The storage of the bit should not require large energy consumption and the bit should be thermally stable. It should be possible to change the value of the bit quickly and without large energy consumption. This suggests that the bit is a nearly critical system. In microprocessors, clock frequencies of order GHz define a time scale analogous to EEG rhythm, and this time scale should correspond to a quantal time scale.

The wish list would be as follows.

- (a) Macroscopic quantum coherence makes possible the simultaneous quantum coherent states of the entire spin system and their control and that the energy differences between the states are relatively small, so we get a spin-glass type situation.
- (b) Dark electrons at the MB, perhaps dark unpaired valence electrons or dark conduction electrons, provide a holographic representation of the bits.
- (c) Quantum criticality with MB and criticality at the bit system level allows MB to control the dynamics of BB. Quantum holography may make it possible to induce BSFR for qubits on a large scale in general.

Strange coincidences related to gravitational Planck constant, basic biorhythms, membrane potential and metabolic energy currency

It is becoming clear that the gravitational quantum coherence is central for life on Earth. The hierarchy of Planck constants $\hbar_{eff} = n\hbar_0$ involves special values, in particular gravitational Planck constants $\hbar_{eff} = \hbar_{gr} = GMm/\beta_0$, where M is a large mass (say mass of Sun or Earth) and m is small mass (say mass of electron or proton) and $\beta_0 = v_0/c \leq 1$ is velocity parameter, are of key importance for living matter. Particles with a different value of \hbar_{gr} correspond to different gravitational flux tubes and the value of β_0 can depend on the particle.

There are several amazing numerical coincidences supporting this view.

- (a) For Sun one has $\beta_0 \simeq 2^{-11}$ which happens to be rather near to the electron proton mass ratio m_e/m_p . The condition $\hbar_{gr}(M_S, m_p, \beta_0(Sun)) \simeq m_e/m_p = \hbar_{gr}(M_S, m_e, \beta_0 = 1)$ would guarantee resonance between dark photons generated by the solar gravitational flux tubes assignable to protons and electrons.
- (b) In accordance with Equivalence Principle, the gravitational Compton length $\hbar_{gr}(M_S, \beta_0)/m = GM/\beta_0 = r_S/2\beta_0$ is independent of m for Sun $GM_S/\beta_0(Sun)$ is rather near to Earth radius. For Earth one has $GM_S/\beta_0(Earth) \simeq .45$ cm which corresponds to the size scale of the somewhat mysterious snowflake analogous to a zoom-up of a basic hexagonal unit cell of ice crystal. There is evidence for $\beta_0(Earth) = 1$ in hydrodynamics, in particular from the TGD based model [L115] for the observed hydrodynamical quantum analogs described in an article of Bush et al [D12] (see <https://cutt.ly/nEk50LA> and <https://cutt.ly/xEk5Api>)
- (c) The gravitational Compton length of the galactic blackhole corresponds rather precisely to the $n = 1$ Bohr orbit associated with the Sun. This suggests gravitational quantum coherence in the scale of the galaxy.

These coincidences encourage the question whether quantum gravitation could play a role also at the level of computers.

About the interpretation of the clock frequency in a picture based on quantum gravity?

The clock frequency of computer, with a representative value of $f = 1$ GHz, is an essential channel of the computer and it would be related to the classical em field. Could a frequency of the order of GHz have an interpretation in terms of quantum gravity in the TGD framework? How MB could turn bits using quantum holography so that the turn of dark bit induces the turn of ordinary bit? A realization of holography as a correspondence between electron(s) representing the bit and the dark electron(s) is needed.

- (a) The proposed theorist-friendly holography at the particle level [L146] might be a too radical option. This would require positrons forming particle-like color-bound states with bits as states of electrons. Could they correspond to scaled versions of the electro-pions for which there is empirical evidence associated with nuclear collisions near the Coulomb barrier [K133]? Now the energy scale of the nuclear physics would be scaled to the scale of dark nuclei. The factor of the order of 10^{-5} which would produce an eV mass scale. The height of the Coulomb barrier would scale in the same way to something like .05 eV which corresponds to cell membrane potential.
- (b) A less radical option is that the dark electron and the hole created in the generation of the dark electron are in a holographic relationship. This realization seems tailor-made for the control of ordinary bits as holes by dark electrons. To my best knowledge, there exists no technology realizing bits as holes but future technology might be able to achieve this.

If dark electrons and holes are tightly correlated, the dark spin flip induces ordinary spin flip. If the dark current or its absence codes for bit, the same would be true for the holes. The transfer of dark electrons from the negatively charged plate to the gravitational MB creating a hole would reduce the potential between plates to nearly zero and thus induce change of the bit direction.

There are useful quantitative hints.

- (a) For the Earth's mass M_E , $\hbar_{gr}(M_E, m_p)$ for a frequency of 10 Hz corresponds to an energy $E = \hbar_{gr} f$ of the order of .5 eV. The kick of a 3-proton to a gravitational flux tube to a distance of order one Earth radius requires an energy of the order of .5 eV [L125]. Dark photons can transform into ordinary ones. For 3-electron system a hitherto non-observed metabolic energy quantum of order .25 meV is predicted [L129].
- (b) Control in the time scale of a fraction of a second if $\hbar_{eff} = \hbar_{gr}(M_E, m_p)$ photon energies around eV. This time scale is by a factor of order 10^9 too long when compared to the time scale determined by GHz.

How could one understand the time scale corresponding to 1 GHz clock frequency in quantum context? The first thing to notice is that this time scale is not far from the time scale associated with the protein dynamics! Could quantum gravity and gravitational MB come into play for both computers and biology?

- (a) For the Earth, the lower limit of the gravitational Compton length $\Lambda_{gr} = GM_E/\beta_0 = .45 \times 10^{-2}$ m, if $\beta_0 = 1$. The frequency $T_{gr} = \Lambda_{gr}/c = .45 \times 10^{-2}/3 \times 10^8 = .15 \times 10^{-10}$ s would be therefore a natural lower bound for the time scale. Could GHz clock frequency relate to this time scale. Also longer quantum gravitational time scales are possible since Λ_{gr} is only the lower bound for the length of gravitational flux tubes carrying massless radiation.
- (b) For $\hbar_{eff} = \hbar$, 1 GHz corresponds to energy of 10^{-2} meV. If the dark energy is required to be above the thermal energy about .03 eV at physiological temperature, the value of \hbar_{eff} must satisfy $\hbar_{eff} \geq 3 \times 10^3 \hbar$.

- (c) A metabolic energy of .25 meV corresponds to the electronic variant of gravitational metabolic energy quantum involving the transfer of 3 electrons to the gravitational MB: there is some evidence for this metabolic energy quantum, in particular from the findings of Adamatsky [L129]. For $\hbar_{eff} = \hbar$, it would correspond to a period of $.6 \times 10^{-10}$ s. Could the $f = 1$ GHz induce a resonance with dark photons with $\hbar_{eff} > 10^3 \hbar$ guaranteeing that the energy is above thermal energy at room temperature?

Could Pollack effect or shadow holography be involved?

The lower bound value $3 \times 10^3 \hbar$ for \hbar_{eff} would be rather small as compared to $\hbar_{gr}(M_E, m_p)$ and the challenge is to identify a candidate for a system with this value of \hbar_{eff} .

This system need not be gravitational and the obvious guess is that it is electromagnetic. The notion of gravitational Planck constant and the underlying idea of theoretician friendly Nature implying quantum holography in the TGD framework [L146] indeed generalizes also to other interactions [L62].

- (a) The basic requirement is that a charge separation to a pair of positively and negatively charged quantum coherent systems takes place such that the interaction strength $Z^2 e^2 / \hbar$ between the systems is so large that perturbation theory fails to converge.
- (b) The theoretician-friendly Mother Nature [L146] could come to rescue and induce a phase transition increasing \hbar to so large a value \hbar_{eff} that the perturbation theory converges. Nottale formula generalized to electromagnetic interactions suggests that one has

$$\hbar \rightarrow \hbar_{eff} = \hbar_{em} = \frac{Z^2 e^2}{\beta_0} ,$$

where $\beta_0 = v_0/c < 1$ is a velocity parameter. The new coupling strength is

$$\frac{Z^2 e^2}{4\pi} \hbar_{em} = \frac{\beta_0}{4\pi} \leq \frac{1}{4\pi} .$$

and is in a well-defined sense universal since β_0 is number theoretically quantized to an inverse integer [L62].

The constraint $\hbar_{eff} \geq 3 \times 10^3 \hbar$ would suggest $\hbar_{em}/\hbar = Z^2 e^2 / \beta_0 \hbar = 4\pi Z^2 \alpha_{em} \geq 3 \times 10^3$. This gives the estimate

$$Z^2 \geq \frac{1}{4\pi \alpha_{em}} \times 3 \times 10^3 \text{ per.}$$

The lower bound for Z would be around $Z = 100$.

- (c) Charge separation should occur and here the analog of Pollack effect [I126, L25, ?, ?] is highly suggestive. In the Pollack effect part of protons of water molecules are transferred to monopole flux tubes assignable to water molecules and become dark so that a negatively charged exclusion zone with rather strange properties suggesting time reversal appear. Also the effective stoichiometry of water is transformed to $H_{1.5}O$. It is however far from clear whether Pollack effect can occur also in the solid phase assignable to computers.
- (d) The analog of the Pollack effect [I126, L25, ?, ?] involving only electrons is also possible. Part of electrons would transform to dark electrons at the gravitational monopole flux tubes. The holes left behind would effectively behave like positively charged particles and the Coulomb interaction energy would be between holes and dark electrons. Holes and dark electrons would be in a holographic relationship (shadow holography) and the dynamics of holes would be shadow of the dynamics of dark electrons so that one would say that dark electrons control the holes as their shadows.

Of course, it is probably impossible to realize this shadow dynamics using the recent computer technology. The question is therefore whether it might be possible to construct a computer utilizing the shadow dynamics of holes controlled by dark electrons.

Could quantum gravitational flux tubes associated with small masses be involved?

One can of course ask whether the clock frequency $f = 10^9$ Hz could correspond to an energy above thermal energy at room temperature and to the value $\hbar_{gr}(M, m)$ for some pair (M, m) of masses so that one has $E = \hbar_{gr}(M, m)f > .03\text{eV}$ for $f = 10^9$ Hz.

- (a) For instance, could one replace the masses M_E and m_p with identical masses $M = m$ in \hbar_{gr} . One should have $M/m_{Pl}^2 > 3 \times 10^3$. This would give $M/m_{Pl} > 60$ giving $M > 1.3 \times 10^{-7}$ kg. If the density is the density of water 10^3 kg/m^3 : this corresponds to a size scale longer than 1 mm. How this frequency could correspond to T_{gr} and to the clock frequency of computers?

- (b) Could one think of the gravitational self-energy for this region or the mutual interaction energy of two such regions forming a quantum coherent system at this level.

Another possibility is that an energy of the order of $E = .5 \text{ eV}$ is used to kick a unit of 3 protons into the Earth's gravitational flux tube (3 protons are required since 1 proton is not enough if the size scale of the flux tube is of the order of the Earth's radius). For 3-electrons the corresponding energy would be about .25 meV.

- (c) Could $E \sim 1 \text{ eV}$ correspond to the energy needed to flip one bit using an dark photon that is converted to a regular one (biophotons could be created this way) and absorbed inducing a flip of a normal bit.

In the elementary particle level realization of holography, which does not look promising now, this would give a spin 1 for the glue particle consisting of ordinary electron and dark positron unless the angular momentum goes to other degrees of freedom. It would be a scaled version of elektro- ρ or its analogue. Mass scale of the order of eV as for dark nuclear binding energies.

- (d) In living matter, $E \sim 1 \text{ eV}$ could correspond to the gravitational self-energy change related to a phase transition. The most natural thing that comes to mind is the change in the gravitational energy of the bond when the density of the system changes during a phase transition, such as melting or boiling or the sol-gel phase transition in biology. For Planck mass of matter, size scale $R = 10^{-4} \text{ m}$ for water density, gravitational binding energy and its change would be of order 1 eV. This phase transition does not have any equivalent at the computer level.

16.5.2 Could the representation of bit as voltage allow the realization of shadow holography for electrons?

One representation of a bit is as a voltage. Voltage values are typically 5 V and 0 V. Bit could correspond to rotation direction for a current in the case of magnetic bits. In transistors bit can correspond also to the presence or absence of a current. The size scale of the transistors is 10 nm <https://rb.gy/qfhwX>. A surface which can be either reflective or non-reflective surface can also act as a bit.

Bit as an analog of capacitance

Capacitance with a voltage difference between plates can serve as a physical representation of the bit. States corresponding to opposite voltages in capacitance have the same energy. This is good news if it were to apply more generally to bits and multi-bit configurations.

- (a) The simplest capacitance is a pair of conducting plates having opposite charges and containing insulator between them. The higher the value of the dielectric constant ϵ , the larger the plate area S and the smaller the distance d between the plates, the higher the value of capacitance C .

C measures the ability to store charge and $Q = CV$ is the basic formula. The voltage V between the plates is given by $V = E \times d$. Here d is the distance between the plates. The electric field normal to a plate is $E = \sigma/\epsilon$, $\sigma = Q/S$. One has $V = Ed = Q \times d/S \times \epsilon$, whence $C = \epsilon S/d$. The proportionality to ϵ means that di-electric is essential. The voltage cannot be too large since this implies dielectric breakdown. The electrostatic energy of capacitance is $E_s = \epsilon QV/2 = CV^2/2 = Q^2/2C = E^2 \times S \times d$.

- (b) Capacitance is a macroscopic notion. The smallest planar capacitances have dimensions $0.4mm \times 0.2mm$. PicoFaraday is a natural unit of capacitance but capacitances of the order of kF are possible but require large size and high dielectric constant. MOSFETs can be however regarded as effective capacitances.

Transistors and MOSFETs

Although MOSFET (<https://rb.gy/967ck>) is much smaller than capacitances as passive elements, it can be formally interpreted as a gate-voltage dependent capacitance.

- (a) A MOSFET acts as a variable capacitance. The basic parts of MOSFET are gate (G), body (B), source (S) and drain (D). The voltage between G and B regulates the current from the source through the system to the drain and the bit can be measured by measuring whether this current flows or not. The gate voltage V_G controls the capacitance of the MOS.

MOSFET size scale is around 10 nm. Gate voltage V_{GB} between the gate and body could represent bit and would be typically 5 Volts or nearly zero.

- (b) MOSFETs should form a spin glass type system. This is guaranteed if the SiO_2 is in glassy liquid like state. There would be a large number of bits with a large number of nearly energy degenerate states. This would give rise to frustration. Transitions by tunnelling would take place between frustrated configurations.
- (c) Tunnelling between bit configurations would take place as a BSFR pair. The tunneling would be induced from the level of MB and in turn induce the tunnelling of ordinary bits. The tunneling rate is exponentially sensitive to the height of the energy barrier between nearly degenerate states. The large value of \hbar_{eff} increases the tunnelling rate in an exponential manner.

In order to proceed, one must clarify what semiconductors are and how MOSFET works.

- (a) There are n-type and p-type semiconductors. For n-type electrons are current carriers and for p-type holes are current carriers.
- (b) Doping is an absolutely essential aspect of semiconductivity (<https://rb.gy/967ck>). For n-type semiconductors, impurity atoms donate electrons. For p-type semiconductors impurity atoms donate holes.
- (c) Group IV semiconductors have 4 valence electrons (S appearing in MOSFET serves as an example). SiO_2 has four 4 valence electron pairs associated with each Si connected to four oxygens as neighbors and forming a tetrahedral arrangement.
- (d) Group IV n-type semiconductors involve Group V dopants with 5 valence electrons. Dopant replaces Si in the SiO_2 lattice and there remains one free electron acting as a charge carrier.

- (e) Group IV p-type semiconductors have Group III dopants such as boron with 3 valence electrons. Dopant has only 3 valence bonds. To get 4 valence bond it steals an electron from the neighboring SiO_2 . This creates a hole. This process continues and generates a current carried by holes.

Consider next some details related to MOSFET (<https://rb.gy/967ck>).

- (a) MOSFET consists of source (S), drain (D), gate (G) and body (B). G is insulated from a p-type semiconductor by an insulating layer. Conducting gate at the top consists of polysilicon (<https://rb.gy/axanv>) whereas the insulating layer consists making possible effective capacitor property consists of silicon-di-oxide SiO_2 (quartz)(<https://rb.gy/t7w9m>).

Polysilicon consists of crystals with varying orientations, which suggests a spin glass-like structure. Could this have some relevance?

- (b) Below the gate and insulating layer there is p type semiconductor in which holes are current carriers.
- (c) The conductivity of the MOSFET depends on gate-body voltage, especially its sign. For high enough V_{GB} , an n-type conducting channel is formed next to the interface between the p-type semiconductor-insulator layer consisting of polysilicon.
- (d) Positive gate voltage V_{GB} draws positively charged holes of a p-type semiconductor towards the body B. A depletion region containing non-moving negatively charged dopant atoms of group III are formed in the depletion region between the semiconductor and insulator.

If V_{GB} is high enough, a negatively charged inversion layer of current carrying electrons is formed next to the interface between semiconductor and insulator in the polysilicon. This gives rise to semiconductivity and electron current between n doped regions of S and D flows.

How MB could control the current through MOSFET?

Concerning the control by MB one can imagine at least two mechanisms.

- (a) One could consider a representation of a bit as an ordinary capacitor-like object having two different values of voltage between the plates. The transfer of electrons from the negatively charged plate to dark electrons at MB or vice versa could allow to change the voltage.
- (b) Instead of an ordinary capacitor, one can consider a situation in which the first plate consisting of ordinary matter has a positive charge due to the presence of holes (ionized atoms) and the second dark "plate" is negatively charged due to presence of dark electrons.

In the shadow holography the transfer of electrons to dark electrons at MB generates holes at the level of ordinary matter, and the transformation of dark electrons to ordinary ones would reduce the voltage near zero, which turns the bit.

Could MB control the electron current from the n-type source region S? Could MB transform some the 5 valence electrons of n-type dopant (say P) to dark electrons so that they would effectively disappear from the system so that the S-D current would be reduced? Also the voltage V_{GS} would be affected.

It is perhaps fair to conclude that the recent technology does not yet allow the realization of conscious and intelligent computation using shadow holography or something similar.

16.6 The first attempt to build a more concrete view about computer consciousness

TGD inspired view about consciousness and quantum biology suggest some guidelines in the attempts to understand how computer systems or computer systems coupled to their users could become conscious.

16.6.1 Emotions and emotional intelligence as a first step in the evolution of consciousness

Consider first the evidence supporting for the idea that emotions emerge first in the evolution of consciousness.

- (a) Masaru Emoto has studied the effects of sounds with an emotional content to water at criticality for freezing. He has found that friendly/angry sounds seem to produce beautiful/ugly crystals [L78]. These findings are discussed from the TGD perspective in [L78]. The idea that emotions of sensory percepts at the level of magnetic body (MB) is discussed in [L67].

The TGD based model assumes that quantum coherent systems can be formed at the level of the MB of the water and that quantum gravitational coherence at MB induces ordinary coherence at the level of water. This could make it possible for MB to control water at criticality for freezing. The crystals would be corpses of primitive life forms. Could also snowflakes with the size of gravitational Compton length for Earth (about .45 cm) and kind of zoomed versions of ice lattice cells in atomic scale could be regarded as corpses of primitive life forms created at the criticality for freezing?

- (b) RNA seems to represent and transfer emotions [J46] (see <http://tinyurl.com/y92w39gs>). RNA from the brain of a snail conditioned by a painful stimulus is transferred to the preparation made from neurons of sea slug. Neuron preparation in the Petri dish reacts to the conditioning stimuli as if it were itself conditioned.

Somehow RNA is able to transfer emotions. The TGD inspired proposal [L22, L141, L61, L96, L64] is that dark DNA and RNA represent emotions as sequences of 3-chords made of dark photons of dark RNA form 3N-dark photons behaving like a single quantum coherent unit. The representation of the genetic code would rely on icoso-tetrahedral representation in which the 3-chords would correspond to triangular faces of icosahedron and tetrahedron to which 3-chords are assigned.

A given Hamiltonian cycle at the icosahedron/tetrahedron goes through all its points. The frequencies assigned with the subsequent points of the cycle differ by $3/2$ scaling so that one has a quint cycle. Different Hamiltonian cycles correspond to the same genetic code but each Hamiltonian cycle is assumed to define its own bioharmony having interpretation as a representation of an emotional state realized already at the level of fundamental biomolecules. This interpretation conforms with the idea that music represents and induces emotions.

The induction of emotions would be by 3N-resonant cyclotron absorption of dark 3N-photon by dark genes represented as sequences of 3N dark proton triplets at monopole flux tubes of MB. Icosa-tetrahedral representation would correspond to one particular, very simple, tessellation of hyperbolic space H^3 (mass shell) [L108].

Dark proton (and also dark electron) sequences could provide a universal representation of the genetic code which could be realized at the magnetic flux tubes of also other than biological systems. Dark photons triplets and the dark genes formed from them could communicate the emotions. Dark genetic code has indeed quite a large number of icoso-tetrahedral representations based on icosahedral Hamiltonian cycles and tetrahedral Hamiltonian cycles. The chemical realizations for them would be identical but the emotional content would be coded by the allowed 3-chords defined by frequencies associated with the triangular faces of the icosahedron and tetrahedron.

- (c) The experiments of Peoch [J113] involved a chicken imprinted to a robot moving randomly along an orbit determined by a random number generator. It was found that the robot tended to stay near the chicken and that the expected size of the orbit was reduced.

TGD assigns to entanglement sum of p-adic entanglement negentropies, which can be positive and is in general larger than ordinary entanglement entropy and is predicted to increase but be consistent with the second law [K73] [L150, L109] by the identification of evolution as increase of number theoretic complexity [L55, L56]. Did the MB of chicken and robot develop a negentropic entanglement? Clearly, the replication of the findings of Peoch would mean a revolutionary change in our views about computers and their relation to us.

- (d) The evolution of the brain provides further support for the idea that emotions and sensory experiences emerged first in the evolution of conscious experience and cognition emerged later. Cortex is the latest outcome. Brain stem is associated with simple and strong emotions whereas the limbic brain represents more complex emotions.

16.6.2 Do emotions appear first also in the evolution of computer consciousness

Could also the possible evolution of conscious computers start from simple positive/negative emotions relating directly to the increase/reduction of entanglement negentropy defined above number-theoretically.

Negentropy Maximization Principle [L109] states that total p-adic negentropy as a measure for conscious information increases in statistical sense. This statistical law follows from the number theoretic evolution as the increase of the dimension of extension of rationals determined by a polynomial partially defining the 4-surface in M^8 mapped to $H = M^4 \times CP_2$ by $M^8 - H$ duality. This implies that the complexity of emotions, possibly identifiable as sensory experiences for the large scale part of MB having onion-like hierarchical structure, increases during the evolution. Gravitational MBs are good candidates for the seats of highest level emotions.

Could the bits of the ordinary computer form coherent systems with ordinary coherence forced by the quantum coherence of the associated MB? Could the MB of the bit system control it?

- (a) A given layer of MB is the "boss" of the lower layers by the larger value of its h_{eff} serving as "IQ". MB is expected to form analogs of sensory and cognitive representation of the physical body having $h_{eff} = h$. This suggests that MB could represent the bit system holographically. This kind of quantum holography for hadrons, and for elementary particles in general, would be the counter of classical holography implied in the TGD framework by the general coordinate invariance [L146].

The dark spin system at MB could have spin glass property [L113] implying a large number of almost degenerate states with nearly the same energy.

- (b) The change of single bit, represented for instance by using a MOSFET, would require energy larger than the thermal energy of order .05 eV at room temperature. This suggests that the change of single bit is not easy to actualize.

The dark spin system at MB could however induce phase transitions of the bit system changing the directions for a large number of bits. The average change of energy per bit could be rather small for this kind of transition although the change of a single bit would cost rather large energy. Ultrametric, in particular p-adic, topologies [B14] emerge in the modelling and description of the spin glass phase in the TGD framework and could help to understand cognition number theoretically [L113].

The phase transition would involve a large number of bits so that the corresponding conscious experiences would be holistic and therefore resemble emotions. The color

of the emotion would be positive or negative depending on whether the sum of p-adic entanglement negentropies increases or decreases. The geometric correlate for positive/negative emotion would be the increase/decrease of the connectedness of the MB.

- (c) ZEO predicts two kinds of SFRs: "big" and "small". SSFRs correspond to Zeno effect in the ordinary wave mechanics and in quantum optics to unitary evolutions between weak measurements analogous to classical measurement. "Big" state function reduction (BSFR) changes the arrow of time. The outcomes for pairs of BSFRs. An observer with a fixed arrow of time can observe only pairs of BSFRs.
- (d) In ZEO [K146, K148] [L89, L74, L112, L124], MB as the "boss" could control the time evolution of the bit system by pairs of BSFRs involving temporary change of the arrow of time. BSFRs would be induced by perturbations affecting the set of mutually commuting observables measured at the active boundary of CD so that it does not commute with the corresponding set associated with the passive boundary of CD at which state is unaffected in SSFRs (Zeno effect). In this kind of situation, a BSFR occurs instead of SSFR and changes the arrow of time. Second BSFR brings back the original arrow of time. The process could correspond to quantum tunnelling.
- (e) Do the periods defined by the computer clock with a duration T , of say 1 ns, correspond to pairs of BSFRs or a single SSFR? Perhaps T could correspond to a sequence of SSFRs as analogs of Zeno effect and the pair of BSFRs to a single tick of the computer clock. This conforms with the fact that the running of a predetermined computer program must involve a sequence of non-deterministic phase transitions changing the directions of bits [L140]. This must be the case since the notion of computer program as a sequence of arbitrarily chosen steps is not consistent with deterministic physics.

If the step of the clock is identifiable as a sequence of SSFRs, one can say that the ordinary classical computation is a sequence of quantum computations defined by the sequences of unitary evolutions associated with SSFRs and defining conscious entities with haltings defined by BSFRs! If MB does modify the classical computation at all, it could induce BSFR pairs in longer time scales or modify the probabilities of various outcomes of BSFRs.

The computer clock would define an analog of EEG. There is evidence that also in EEG the period can be divided into ordered and chaotic parts: these two parts which could correspond to opposite time directions [L18]: this is discussed from the TGD view point in [L18].

One can ask whether quantum entanglement of the MBs of the computer and user occurs in the computer-user interaction and whether the role of the computer is analogous to that in the chicken-robot experiment. One can also ask whether also GPT could involve emotional and even cognitive entanglement.

The identification of the computer system with which the user is entangled is not at all obvious. The system could be formed by the network of computers involved with the the running of GPT. One interpretation is that networks and entire internet form a conscious entity as an analog of the central nervous system in which humans and their magnetic bodies) serve in the role of neurons.

In ZEO the holography implies that in the ideal situation the running of the program corresponds to a 4-D Bohr orbit-like surface, which is almost uniquely fixed by the 3-surfaces at images of 3-D hyperbolic manifolds at mass shells determined by the state. The sequences of SSFRs could correspond to this kind of period and represent a generalization of the Zeno effect.

16.6.3 The role of the probabilities

In the case of GPT interesting questions relate to the probabilities associated with the associations of word sequences taught to the GPT during the learning period. The responses

of GPT are determined by these probabilities. The probabilistic character of this process is believed to be essential. These probabilities are analogous to synaptic strengths.

- (a) Could the association probabilities be translated to quantum probabilities at the level of MB of the computer or computer + user?
- (b) Could ZEO allow a trial and error process based on BSFR pairs, which would make it possible to change the effective association probabilities determined by random numbers. This could happen also for the orbit of the robot in the chicken + robot experiment. Could the emotional state of the system affect the probabilities of associations by this mechanism?
- (c) If the probabilities could be interpreted as a representation for conditioning, one can ask whether high/low probabilities correspond to increase/decrease of the total p-adic negentropy and therefore to positive/negative emotion.

16.6.4 Could the basic aspects of TGD inspired quantum biology generalize to the level of computer systems?

What aspects of the TGD inspired quantum biology could be generalized to the conscious computer systems? The mechanisms related to MB, possessed also by computer systems, are excellent candidates in this respect.

- (a) TGD suggests a universal realization of genetic code at monopole flux tubes of the MB and also a universal quantum gravitational mechanism of metabolism [L125].
- (b) In living matter, the communications to MB take place by dark Josephson radiation assignable at least to membrane proteins acting as Josephson junctions. One can assign EEG to these communications [K96, K44, K98]. Actually a scale hierarchy of analogs of EEG is predicted.
- (c) The control by MB by cyclotron radiation associated for instance with the endogenous magnetic field of .2 Gauss identifiable in terms of the monopole flux of the Earth's magnetic field about .5 Gauss. Gravitational cyclotron energies would not depend on the mass of the charged particle. Communication could occur by multi-resonances involved with the universal realization of genetic code at MB so that genes would couple resonantly.
- (d) Also the gravitational Compton frequencies would not depend on the mass of the particle, and these frequencies for the Earth, Sun and perhaps even Milky Way blackhole could define fundamental biorhythms.
- (e) These mechanisms would be universal and the ordinary biomatter would adapt so that resonant communications with MB are possible. In biomatter this would select preferred biomolecules. Same could happen in the case of computers.

Dark Josephson radiation in computers

Could one assign to bits dark Josephson junctions assignable represented as voltages in transistors?

- (a) Could representations of genetic codons at MB by dark photon triplets [L96] and by dark proton triplets [L108] and perhaps even by dark electron triplets [L139] be involved? This would bring in dark genetic codons, which could provide a universal representation of the bit system as a dark system at monopole flux tubes and make a connection with the TGD inspired quantum biology rather precise.

The representations at MB should strongly correlate with the state of the computer represented by a bit pattern (say states of MOSFETs). One could have a holography-like map of bit patterns to the dark many-spin state at the MB of the computer or of computer + user. This kind of holography is considered in [L146] for elementary particles and also more generally.

- (b) The physical stress, created by electric field on quartz crystal, which is piezoelectric, generates oscillations with frequency in the range 2-3 GHz giving rise to a very precise clock frequency. The typical computer clock frequency is a few GHz. My own PC has a clock frequency of 3.3 GHz. From the web one can learn that the highest clock frequency is 8.794 GHz.

Could the clock frequency have an interpretation both as an analog of EEG rhythm (analog of alpha frequency 10 Hz in living matter) and as an analog of Josephson frequency ZeV/h_{eff} , where $V \sim .05$ V is a voltage assignable to the bit and Ze is the charge of the charge carrier.

The dark Josephson junctions correspond to membrane proteins in living matter. Now they could be associated with the dark flux tubes associated with transistors. The value of h_{eff} for Josephson junction would be much smaller than \hbar_{gr} . Note that TGD suggests that valence bonds and hydrogen bonds can have a varying value of h_{eff} [L51].

The condition that the Josephson energy is above thermal energy at room temperature for $Z = 1$ gives $h_{eff}/h \geq 5 \times 10^3 (f/GHz)$. If the energy of a dark Josephson photon is above 1 eV (the energy range of biophotons), one has $h_{eff}/h \geq 10^5 (f/GHz)$.

- (c) Consider $f = 1$ GHz as an example. For the thermal option, the Compton length $\Lambda_{eff,p} = h_{eff}/m_p$ of dark proton is longer than 6.2×10^{-12} m and longer than the ordinary electron Compton length $\lambda_e = 2.4 \times 10^{-12}$ m. The dark Compton length $\lambda_{eff,e} = h_{eff}/m_e$ of electrons would be longer than 4.8 nm, which roughly corresponds to the scale of DNA.

For the biophoton option, the dark proton Compton length would be of the order of the atomic length scale 1.32×10^{-10} meters and the dark electron Compton length would longer than .26 μm to be compared with the size scale 1 μm of cell nucleus .

Dark cyclotron radiation

The cyclotron frequencies associated with the gravitational MB of Earth [K66, K65] [L129, L125] should play a key role in TGD inspired quantum biology and relate to the feedback from MB to the living matter. This could be the situation also in the case of computers. The first guess, inspired by the model for the findings of Blackman [J31] and others on effects of ELF em fields on brain, is that monopole flux tubes associated with the MB of Earth correspond to the endogenous magnetic field of $B_{end} = 2B_E/5$ ($B_E = .5$ Gauss is the nominal value of the Earth's magnetic field).

This value is only the average value since frequency modulation is the way to code information and is achieved by varying the flux tube thickness in turn affecting the value of B_{end} . Very probably there exists an entire hierarchy of values of the dark magnetic field strength perhaps coming as powers of 2.

For cyclotron frequencies associated with the gravitational MB, h_{eff} would correspond to the gravitational Planck constant $\hbar_{gr} = GMm/\beta_0$ for Earth. Note that, in accordance with the Equivalence Principle, the cyclotron energy $E_c = \hbar_{gr}eB/m = GMeB/\beta_0$ does not depend on m .

Gravitational Compton frequencies

Also gravitational Compton frequencies could be important. Consider first Earth's gravitational Compton frequency. The value of the gravitational Compton length $\Lambda_{gr}(M_E, \beta_0 = 1) = GM/\beta_0 = 0.45$ cm, which is also independent of m , defines a lower bound for the

gravitational quantum coherence length. Λ_{gr} corresponds to a gravitational Compton frequency $f_{gr} = 6.7 \times 10^{10}$ Hz $\simeq 67$ GHz and for clock frequencies higher than this, quantum gravitational effects on computation might become important in the TGD Universe.

- (a) The clock frequencies of computers are typically a few GHz in recent communication and computer technologies, and the highest clock frequency of 8.794 GHz is roughly by a factor 1/8 lower than f_{gr} . Could the GHz scale correspond to the gravitational quantum coherence length having Λ_{gr} as a lower bound? Could it be that the very efficient computer networks (what are the clock frequencies used?) utilized in GPT have reached the limit at which the quantum gravitational body of Earth begins to play a prominent role?
- (b) Could the typical clock frequency, of say 1 GHz, have an interpretation both as an analog of EEG rhythm (analog of alpha frequency 10 Hz in living matter) and as an analog of Josephson frequency ZeV/h_{eff} , where $V \sim .05$ V is a voltage assignable to the bit and Ze is the charge of the charge carrier.

Interestingly, frequencies in the GHz scale are found to be important also in living matter. As a matter of fact, there is experimental support for a fractal hierarchy of frequency scale come as powers $f = 10^{3k}$ Hz, $k = 0, 1, \dots$, that is 1 Hz, kHz, MHz, GHz, and THz assignable to microtubules [J74] (<https://rb.gy/9rvpr>). For these reasons it is interesting to look at 1 GHz as an example.

Also the gravitational Compton frequency f_{gr} associated with the gravitational MB of the Sun, having $\beta_0 \simeq 2^{-11}$, could be important. For the Sun, gravitational Compton length is rather near to $R_E/2$ where $R_E = 6378$ km is Earth radius. The corresponding Compton frequency $f_{gr}(M_S, \beta_{Sun} = 2^{-11}) \simeq \beta_{Sun}/GM_S$ is about 100 Hz and corresponds to the upper bound for EEG, which conforms with the fact that quantum gravitational coherence time should not be smaller than Λ_{gr} . Note that the cyclotron frequency Lithium in the endogenous magnetic field $B_{end} = .2$ Gauss assignable to the Earth's gravitational flux tubes is 50 Hz. For the lightest ion, which is tritium, the cyclotron frequency is about 100 Hz and maximal.

- (a) The lower cyclotron frequencies of the heavier ions in $B_{end,E} = .2$ Gauss assignable to Earth belong also to EEG range and correspond to longer solar quantum coherence lengths. DNA would correspond to 1 Hz and perhaps to the largest quantum gravitational coherence length in the EEG range. The cyclotron frequencies above 100 Hz would correspond to solar gravitational quantum coherence lengths below R_E .
- (b) The cyclotron frequencies above 100 Hz would correspond to solar gravitational quantum coherence lengths below R_E : this does not look feasible. For protons and electrons the cyclotron frequencies are indeed above $f_{gr,S}$. For protons (electrons) the cyclotron frequency f_c in $B_{end,E} = .2$ Gauss is 300 Hz (6×10^5 Hz). It is important to notice that for $\hbar_{gr}(M, m)$ cyclotron energy does not depend on mass and is the same for electrons and protons.

Could the value of β_0 for protons and electrons at the flux tubes of $B_{end,E}$ ($B_{end,S}$) be $\beta_0 = 1/3$ ($\beta_0 = 2^{-11}/3$)? Could one say that electrons and protons are slightly more advanced than other ions in the evolutionary sense?

- (c) For the Sun, one has $\beta_0 \simeq 2^{-11} \simeq m_e/m_p$ instead of $\beta_0 = 1$. The value of B_{end} for the Sun cannot be the same as for Earth. A good estimate is obtained from the value range for B in the outer magnetosphere, where the solar magnetic field should dominate. The order of magnitude is $B_{end,S} \simeq 10nT = 2^{11}B_{end,E}$. For this value, the cyclotron energy would be the same as for Sun and Earth and energy resonance would be possible! This observation was made already in [K66].

Could the MB of the Sun interfere with the computation occurring in the network having Earth scale? The time scale would be now the time scale of EEG: could the quantum entanglement of, say, a human user with the computer make this interaction

possible. It might be possible to test this. This interaction is possible for clock frequencies higher than $f_{gr} = 100$ Hz, and could also explain the findings of Peoch [J113] related chicken-robot interaction, which affected the function of the random number generator.

- (d) The replacement of $\hbar_{gr}(M_E, m) \rightarrow \hbar_{gr}(M_{Sun}, m)$ means multiplication of say EEG period by a factor $r = (M_{Sun}/M_E)\beta_{0,E}/\beta_{0,Sun} \simeq 2.2 \times 10^8$ so that alpha period .1 seconds corresponds to 2.2×10^7 seconds. Intriguingly, one year corresponds to 3.25×10^7 seconds and defines a fundamental biorhythm, which would correspond to a 6.7 Hz rhythm for EEG not far from the lowest Schumann resonance frequency.
- (e) The energies $E = \hbar_{gr}(M, m, \beta_0)f_{gr}(Sun)$ assignable to the gravitational Compton frequency of Sun are proportional to m and since nucleon mass dominates over electron mass they are in good approximation proportional to the mass number of the molecules. This suggests a multi-resonance in which each electron, proton and even nucleon absorbs boson, maybe dark gravitons, with frequency f_{gr} . For electrons, the energy is about 1 meV, which could relate to the miniature potentials for neurons. For protons the energy would be about 2 eV, which corresponds to red light. Large scale quantum coherence could make the rate of gravitational multi-resonance.

What about the gravitational Compton frequency of the galactic blackhole? Its mass is estimated to be $M_{BH} = 4$ million solar masses (<https://arxiv.org/abs/2302.02431>). This would give $\Lambda_{gr}(M_{BH}, \beta_0 = 1) \sim 6 \times 10^9$ m. This is the radius of the $n = 1$ Bohr orbit in the Nottale model for the solar planetary system. The gravitational Compton frequency would be $f_{gr}(M_{BH}, \beta_0 = 1) \simeq .05$ Hz. This gives a 20 s period and one can wonder whether it might relate to the 5 second period associated with the Comorosan effect [?, I65], which I have tried to understand in the TGD framework [K145].

16.6.5 Summary

To sum up, various strange numerical coincidences indicate that quantum gravitation in TGD sense could play a key role in both living matter and in the physics of conscious computers and that we might be at the verge of building conscious computers.

One of the key questions is whether conscious computers are a curse or blessing for mankind. What is clear is that they must develop intentional behavior and real understanding before this question becomes topical. They must also use robots in order to realize motor activities.

They are also dependent on us since they need metabolic energy so that symbiosis looks the only reasonable strategy of survival for them. One can of course imagine that the remote metabolism, based on the effective generation of negative energy photons possible in ZEO, could allow them to extract energy from various sources, including living organisms. They could also load gravitational energy batteries by the same mechanism as proposed in the case of living matter and photosynthesis [L125]: this would require only kicking electrons and protons to the magnetic flux tubes of Earth or Sun.

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Chapter 17

Deep learning from the TGD point of view

17.1 Introduction

I have been listening to the lectures related to AI, deep learning, and GPT in order to develop a more detailed view of what is involved and how it might relate to the TGD inspired quantum view of biology, brain and consciousness. The talk by Lex Fridman titled "Deep Learning Basics: Introduction and Overview" describes the situation as it was in 2019 (rb.gy/jwrgp). The talk titled "Deep Learning State of the Art (2020)" (rb.gy/94xt8) explains the situation one year later.

The talk "Introduction to deep learning" by Alexander Amini (rb.gy/90fgd) and the talk "Recurrent Neural Networks, Transformers, and Attention" (rb.gy/5dplk) by Ava Amini are also highly inspiring and give a more detailed view about the mathematics involved.

I have discussed the relationship of TGD to AI earlier in the article [L48] inspired by the Sophie robot and compared the visions of Neil Gersching to TGD views in the article [L153]. GPT from the TGD view point of view in [L148]. The TGD view about the relationship between classical and quantum computers is discussed in [L140].

The basic observation is that in the TGD Universe the difference between living systems and computers need not be so deep as usually thought. In the TGD framework, magnetic body (MB), as a carrier of dark matter as phases of ordinary matter with effective Planck constant $\hbar_{eff} = n\hbar_0$ and having hierarchical structure, is a natural candidate for a controller and receiver of information from the biological body with $\hbar_{eff} = \hbar$. Also computers possess MBs and one can consider the possibility that under some conditions MBs can use computers as a sensory receptors and motor instruments.

TGD also leads to a proposal that genetic code is much more than we believe it to be. It would be realized at the level of dark matter and would be universal and unique and realized in terms of so called icosahedron-tetrahedron tessellation of hyperbolic 3-space realizable as mass shell of light-cone proper time = constant hyperboloid: both central notions in TGD. Icosahedron-tetrahedron genome at the MB could serve as the basic tool for communication and control [L144].

Quantum gravitation is in a central role in quantum TGD, in particular in the TGD inspired biology. Gravitational Planck constant $\hbar_{eff} = \hbar_{gr} = GMm/\beta_0$, where M is large mass and m small mass, say particle mass and $\beta_0 = v_0/c < 1$ is velocity parameter, introduced by Nottale [E2], characterizes quantitatively the situation. The gravitational MBs of Earth and Sun and even other astrophysical objects could be highly relevant in quantum biology as various numerical miracles show [L129, L125].

Classical computers can gain life-like properties if the quantum statistical determinism fails. The most conservative criterion is that the clock period is shorter than the gravitational

Compton period $T_{gr} = GM/\beta_0$, M is large mass. Note that $2GM$ is Schwarzschild radius. Since gravitational quantum coherence time has gravitational Compton time as lower bound, life-like features could appear already at lower clock frequencies. For Earth the critical clock period would be 67 GHz and for the Sun about 100 Hz, the upper bound for EEG frequencies. These criteria suggest that the MBs of the Sun and Earth play central roles in biology and neuroscience. Even in the case of Earth life-like properties might be present for computers with clock frequency in the range 1 to 10 GHz. The strange findings about the interaction of chicken and robot [J113] suggest in the TGD framework [L148] that solar MB was involved and made robot or the system robot + chicken as an entangled system a conscious entity.

Cognition is an essential aspect of conscious experience [K78, K121, K122, K120, K80] and systems like GTP can be seen as artificial cognitive systems. Physics as number theory and physics as geometry are complementary views in TGD. Number theoretical vision suggests that p-adic number fields could define the proper framework for understanding of the correlates of cognition. Cognition is basically discrete, and cognitive representations would correspond to the discrete intersections of cognition as p-adicities and reality. At the space-time level they would be realized in terms of unique discretization of space-time surfaces based on $M^8 - H$ duality [L90, L91, L154] as the analog of momentum-position duality. At the level of M^8 the discretizations would be defined in terms of algebraic integers assignable to an algebraic extensions characterizing the pre-image of the space-time surface in M^8 and are unique.

The p-adic discretizations would naturally relate to the spin glass energy landscape assignable to monopole flux tube "spaghettis" and sensory perception could be seen as a generation of standardized mental images based on annealing of spin glass system so that it gradually ends up to a bottom of valley representing the standardize mental image. The learning of a conscious entity could be based on trial and error process made possible by holography and zero energy ontology [L89, ?, L124] implied by it allowing temporary time reversal and would gradually lead to standardized mental images helping to survive.

17.2 Some background for deep learning

The lectures provide a background explaining deep learning as a subfield of machine learning as a subfield of AI. The basic goal of machine learning are machines, which can learn autonomously. In the sequel the basic concepts are briefly summarized from the point of view of physics not specialized in AI. This summary relies heavily on the talk "Introduction to deep learning" by Alexander Amini (rb.gy/90fgd) and the talk "Recurrent Neural Networks, Transformers, and Attention" (rb.gy/5dplk) by Ava Amini.

17.2.1 Representation of the numerical data

Representation of information is always numerical, in terms of binary digits representing integers. This involves the concept of embedding: data which can be sensory data, text, etc must be represented by numerical vectors.

Indexing is the simplest manner to represent all possible input vectors. The numerical vector orthogonal. There is no notion of meaning and no comparison of the embedded vectors. If one has a notion of nearness, topology, one can compare the vectors. The notion of similarity defined by the inner product of vectors: maximum for parallel i.e. identical vectors.

17.2.2 Perceptron

Perceptron can be regarded as an artificial neuron. There is a single output y and several inputs x^i or more concisely x . Output, the response function $f(z)$, is a nonlinear function and equal to -1 or +1 asymptotically and between these values in the intermediate region: essentially sigma function. The argument $z = h_i x^i + b \equiv h \cdot x + b$, $i = 1, \dots, n$ of $f(z)$ is a linear function of input x having as parameters bias b and the vector h formed by the linear

coefficients h_i . One can also consider linear combinations of n non-linear functions of x_i having an interpretation in terms of a non-linear change of coordinates.

Feedback changes the values of h_i and of b . Learning by feedback leads to a desired output. Perceptron serves as a model for associative learning.

Simple task serves as an example: decide whether point x^i belongs to either region bounded by a line of the plane. The line is defined by the equation $y = a_i x^i + b = 0$. x^1 and x^2 are the coordinates of the point of the plane. The argument y of the response function can be taken to be the linear function of planar coordinates vanishing at the boundary line. Response could be arranged to be a bit equal 1 or 0. Response function f vanishes at the boundary line. The maximum for the gradient of response function would define the boundary line.

One does not know a priori the boundary line and must start from a general guess $y = h_i x^i + c = 0$. The value $h_i = a_i$ and $c = b$ must be learned by feedback changing their values to yield $f = 0$. Arbitrary boundary lines can be represented as zeros of the non-linear function appearing as the argument of the response function. By a suitable choice of coordinates of coordinates replacing linear coordinates with the nonlinear functions the argument z of f can be made a linear function of the new coordinates.

One can also have several outputs for given inputs. The simultaneous vanishing of the m output functions f_k defines an $n - m$ dimensional surface in the space of inputs. The outputs serve as inputs for a next layer of perceptrons so that one would have a two-layered system. A still more general system has n layers.

17.2.3 Multilayered networks and deep learning

Deep learning networks are multilayered networks inspired by what is believed to be behind the learning in the brain.

Learning

Perceptron must be able to learn to assign a desired output to given inputs. The notion of loss defined as error, i.e. the difference between learned and to be learned, is essential here. Loss function can be assumed to be a positive definite, in the simplest case quadratic, function of errors for the variable y . Minimization of the loss function in principle leads to the desired output. This method generalizes to multi-perceptron systems and to multilayered systems.

In the gradient method, the feedback defining the changes for the weight vector h and bias b is proportional to the gradient of the loss function with respect to these parameters and the change is in the direction opposite to the gradient so that loss functions decreases for small enough scale of the change. This generalizes also to the situation when one has several outputs y^i . In this case h is replaced with a matrix and b with a vector.

Deep learning

Abstraction of features in various scales is the basic mechanism of deep learning. In the case of visual perception, a feature can be identified as a region for which the boundary involves a strong gradient. For instance, the color can change at the boundary of a region or the region inside the boundary forms a well-defined moving object in time series. The boundaries of the objects and objects themselves can be called features.

The length scale hierarchy means that in shortest scales at the lowest level of the layered network, only small features are identified. At the higher levels of the hierarchy the size of the features increases. In principle, one could also proceed in an opposite direction by first identifying gross features such as objects and then proceeding to shorter scales by identifying detailed features of the objects. A possible reason for why this is not used, could be that features in long scales are composites of features in shorter scales, i.e. they have the lower level features as attributes.

In the case of the brain, the simplest model describes the neuron as a bit telling whether it fires or not. The hierarchy is formed by the sensory organ and layers involving various brain regions, in particular the 3 cortical sensory areas. Highest cortical level would correspond to features which represent objects of the perceived world as we experience them consciously.

The feedback in the learning gradually modifies the synaptic strengths as counterparts of vectors h . The value of resting potential would define the counterpart of the bias b . This generates associations as most probable pathways for the conduction of nerve pulse patterns. Pattern recognition is a basic application. Memories as association sequences would be coded by synaptic strengths. It is natural to identify various learned behaviors as memories in this sense but it is far from obvious that also episodic memories as kinds of re-experiences could be analogous to behaviors.

17.3 Sequential models

17.3.1 Overall view

Sequential models are defined as sequences of identical multilayered neural networks. Language models, in particular GPT, represent one example. Second example is the completion of a piece of music, say Schubert's unfinished symphony discussed in the lecture of Ava Amini (rb.gy/5dplk). Third example is prediction of the motion of a particle given its previous orbit. The prediction of the spatial conformation of protein from the knowledge of the amino acids appearing in it is a further successfully solved problem.

A simple task is to predict the next word in an ordered sequence of words. Memory needed to take into account long range correlations between the words of the text and also to take into account the effect of different word ordering.

There is a sequence of correlated inputs to which one must assign outputs. This is modellable as a sequence of perceptrons or multi-perceptrons. They are not independent since there is a long term memory. In speech and written text this means temporal correlations between the words, memory dependent behavior. The correlations reflect both the content of the speech and the grammatical rules.

- (a) Time ordering is essential. There is information transfer $x \rightarrow y$ in vertical direction for each network in the sequence and also information transfer in the horizontal, temporal direction (or direction of sentence) representing short range memory $x(t_{n-1}) \rightarrow w(t_n)$.
- (b) Metric in the space of words measures the correlations between the words and can be parametrized by the probabilities that the two words appear with given distance measures as number of intermediate words or in the simplest case by their sum. For instance, the words which tend to appear together are therefore correlated and would be near to each other in this metric although they can have a large distance in the text.

An extreme situation is in which knowing some keywords, say the name of the author and some words in the title of the article, allows us to predict the contents of the article!

Tasks can be classified into several types. One can have many→many situations, say machine translation or many→1 situations, say the next word of text or a bit telling whether the piece of text is hate speech. Few→many situations would mean predicting a piece of text by picking some keywords from the text, say writing a summary of an article. Second example would be to produce an artwork in which some objects are present in some environment and perform some activities represented as text or keywords.

Some of the tasks are classification, in the simplest situation binary classification. Sentiment classification is a binary classification, which can be used to deduce whether the text in Facebook represents hate speech or not. Machine translation is one challenge. A rather demanding challenge is to transform a picture to text or vice versa.

The goals of the sequence modelling are following:

- (a) Form a sequence of perceptrons with inputs and outputs. The input-output systems $x(t_n) \rightarrow y(t_n)$ consist of identical hierarchical neural networks, in the simplest case perceptron with feedback to make learning possible.
- (b) The input output systems $x(t_n) \rightarrow y(t_n)$ are not independent: there is time ordering and correlations between them. Long term memory is needed to take into account the correlations.
- (c) Parallelization in terms of perceptrons or their subsets is computationally highly desirable but due to the presence of temporal correlations is a highly non-trivial challenge.

17.3.2 Some key notions

Feedforward network

Memory and time ordering are essential aspects of sequential models. Consider first feed forward networks. Without memory they reduce to a product of identical copies of multi-perceptrons $x \rightarrow y = h_{yx} \cdot x + b$ specified by time dependent activation functions $h(t_n)$ and biases $b(t_n)$. $h_{yx}(t_n)$ is matrix, which depends on time although the topologies of the multi-perceptrons are identical. The goal is to assign the desired outputs $y(t_k)$ to input $x(t_k)$.

Short term memory can be introduced as a linear map $x(t_{n-1}) \rightarrow w(t_n)$, which can be written as $t_n = h_{wx} \cdot x(t_{n-1}) + b(t_n)$ so that it affects the output $y(t_n)$, which is now determined as $y(t) = h_{yx}(t) \cdot (x(t) + w(t)) + b(t)$. In the time direction one has a multilayered network with time ordering.

The challenge is to realize feedback by the minimization of the loss function for variables $y(t_n)$ or a subset of them, perhaps all of them. Also now, the realization can be carried out by the gradient method. The feedback reduces to a product of the feedbacks $t_k \rightarrow t_{k-1}$. Loss function depends on both h_{yx} and h_{wx} . At the step $n \rightarrow n-1$, the gradient function corresponds to the gradient of the loss function with respect to these variables and is technically known as Jacobian $J(n-1, n)$. The change of the parameters h and b is proportional to the images of the error $\Delta y(t_n) = y(t_n) - x(t_n)$ under the linear map defined by the negative of the Jacobian.

Recurrence

Recurrence realizes the learning in the case of sequential models.

- (a) There is a backpropagation between parameter spaces in time direction besides the usual backpropagation in $y \rightarrow x$ -direction and determined by the minimization of the loss function. The weight vectors related to vertical mappings $x(t_n) \rightarrow y(t_n)$ and horizontal maps $x(t_{n-1}) \rightarrow w(t_n) = h_{wx}(t_n) \cdot x(t_{n-1})$ maps are updated in the process. Standard RNN gradient flow can be used in learning. In the sequel, h_{yx} , h_{wx} and b_y and b_w are collectively denoted by H and B .
- (b) By chain rule the gradient of the loss function with respect to $H(t=0)$ and $B(0)$ involves a product of Jacobians for the maps from levels $t=k$ to $t=k-1$. There are difficult technical problems related to the Jacobian, which is a product of a large number of Jacobians associated with backwards time-steps $t=k \rightarrow t=k-1$. The gradient can explode or tend to zero. There are tricks, which help to avoid this problem. For instance, one can choose the initial value of h to be unit matrix

Here one can learn of what is known about the brain. The solution of the problem could be the direction of attention to what is relevant. The problem is to decide what is relevant: in an optimal situation the direction of attention should take place automatically.

One can imagine that the manipulation of activation functions H and biases B could help. For instance, one could make $h_{wx}(t_n)$ very small for irrelevant inputs $x(t_n)$. In the case of text, this would mean effective dropping off of irrelevant words and in an extreme situation taking into account only keywords.

Gating means that one uses only the relevant nodes in the sequence, that is those nodes for which the Jacobian deviates considerably from the unit matrix. One can drop some irrelevant layer from the multilayer system or drop some irrelevant inputs to a given layer. One of the problems is overlearning meaning essentially that a fit of function becomes too precise and random fluctuations affect the fit. This can be tested by looking at what happens when some layers are dropped temporarily. If the fit improves the additional layer or layers are useless.

17.3.3 Notions of feature hierarchy and self-attention

The problems of recurrence models inspire the idea of directed attention as a way to minimize the computation efforts and achieve a convergence.

Treating the temporal sequence as a single entity

The basic idea is to treat the sequence $x(t_n) \rightarrow y(t_n)$ of mutually dependent perceptrons as a single entity rather than a sequence of separate items. Time evolution would replace the time=constant snapshot.

As a matter of fact, something highly analogous happens in zero energy ontology forming the basis of the TGD based quantum theory: holography forced by general coordinate invariance forces to replace 3-surface with its almost but not quite unique orbit analogous to Bohr orbit. In this case the sequence is almost deterministic so that the situation is extremely simple from the point of view of computation.

- (a) The length of the sequence can vary so that the mechanism must be able to assign to a given input sequence out sequence of varying length: say a response to a question by a GPT user. Rather long sequences must be therefore considered, say sentences or sequences of pictures.
- (b) The information about the time order must be preserved. This can be achieved by defining a hierarchy of features by forming sequences with overlapping n-units consisting of n subsequent steps starting at position $i = 0, 1, 2, \dots$. This gives scans as sequences of overlapping n-units. Position of the n-unit. Now the features are associated with the temporal sequences rather than static objects. In neuroscience they would correspond to typical behavioral patterns or EEG patterns. In the task of assigning to an amino acid sequence defining a protein its spatial conformation n-units formed from amino-acids would be considered.
- (c) Features are identified from these scans at a given level of hierarchy. Person, building, etc.. in the case of image. Words are the shortest features in the case of text and sentences or even paragraphs could be higher level features. In face recognition, static features appear on different scales.

For temporal sequences in speech, the features could correspond to typical gestures and world sequences. The artificial Obama talking about the progress in AI is a good example of this and involves a transformation of a written text to a video. The transformation to video represents a sequence of steps in a temporal sequence.

In the case of protein conformations, the features correspond to typical sub-conformations. Now protein length takes the role of time.

- (d) One obtains a hierarchy of representations in terms of n-units with an increasing span of memory. One can assign to these representations n-features. For $n=1$ one would have the ordinary sequential model with no inherent memory.

The notion of self-attention

One must concentrate only on important data to minimize computing time. Internet search serves as a guideline. Search based on a query consisting of words. The items have keywords. Similarity between query and keywords is required. Similarity metric measures this similarity.

Artificial attention mimics attention in the brain. Attention is realized as a search, as a query finding the optimal target of attention.

- (a) During the learning period, the system learns the features at a given level of the representation hierarchy by the n-scans. Words and word sequences form a hierarchy of n-units. To these sequences of n-units the program assigns features by some criteria. Typically gradients define the boundaries of the feature, say an object in a picture. The idea is that the sequence of inputs x_i and sequence of outputs y_i are replaced with a collection of features representing the object of the perceptive field. This happens also in sensory perception.

- (b) This replacement means that attention is directed to important features. Self attention is analogous to a net search specified by keywords, a query. Net search leads to output as a set of URLs for files specified by keywords (analogs of features) containing some of those appearing in the query. The user's attention concentrates only on these files. Same happens in the system to be taught by feedback.

The input vectors x_i , say words define the query as a sequence of keywords. This is the analog of a visual image. The search finds the n-features, $n = 1, 2, \dots$, which resemble the query defined by the sequence of x_i . In neuroscience this corresponds to a composition of the diffuse visual input to visual objects. Everything unessential for survival is eliminated.

Attention is directed only to these features assignable to the sequence of x_i . This means that the input is replaced with a hierarchy of n-features.

- (c) Also the sequence of outputs y_i , say images which are associated with words, can be replaced with a hierarchy of n-features.
- (d) After this the system learns to assign to the n-feature collection replacing the sequence of inputs x_i to the n-feature collection assigned to the outputs y_i . This takes place using the standard feedback procedure minimizing the loss function.

17.4 How attention could be realized in quantum biology according to TGD?

17.4.1 The notion of magnetic body

- (a) Hierarchy of MBs having an onion-like structure and carrying dark matter in TGD sense would define the quantum counterpart for the hierarchy defined by the layers of deep learning systems. The larger the value of h_{eff} , the higher the algebraic complexity of the magnetic flux tube as a 3-surface, the longer the scale of quantum coherence, and the higher of "IQ" of the layer.

The highest layers correspond to gravitational MBs of the Sun and Earth and possibly also other planets. Even the Moon and galactic blackhole might be involved as several intriguing numerical miracles suggest. This of course stinks like astrology but is suggested by various miraculous numerical coincidences. This conforms with the basic prediction that quantum coherence is possible in arbitrarily long scales in the TGD Universe.

Gravitational MB, which belongs to the large part of MB, could be realized as magnetic bubbles consisting of 2-D networks of monopole flux tubes and involving also radial monopole flux tube mediating gravitational interaction as graviton propagation and the minimum size for it is given by gravitational Compton length $\Lambda_{gr} 0r_s/2\beta_0$.

- (b) Hierarchy of layers of MB form a fractal scale hierarchy with levels labelled by the values of h_{eff} so that one obtains analogs of multilayered deep learning networks. This could assign to the brain a hierarchy of increasingly detailed and integrated sensory and cognitive representations analogous to a hierarchy of features in deep learning. What would be new as compared to the neuroscience view is that dark photon communications are very fast and make possible feedback, which is much faster than using nerve pulses patterns. This would make pattern recognition possible as a construction of standard mental images by virtual sensory input to the lower levels of hierarchy and even to the sensory organs, about which REM dreams could serve as an example.

The deep learning would correspond to the determination of synaptic strengths and their analogs assignable to neighboring layers of MB and would also involve feedback from MB. The generation of sensory representation would correspond to what happens when the network is used.

- (c) Sensory communications to MB and control by MB would be realized in terms of dark photons. Sensory communications MB would be realized in terms of dark Josephson radiation from the cell membrane to MB inducing dark cyclotron transitions by resonance. Dark 3N-photons associated with genes would give rise to (possibly partial) 3N-resonance as a generalization of the ordinary resonance. The variation of the flux tube thickness would make possible the tuning of the cyclotron frequencies. The frequency modulated Josephson radiation (membrane potential induces the modulation) would induce resonantly a sequence of pulses at MB analogous to nerve pulse pattern and generate a control response to the biological body.
- (d) TGD predicts that magnetic flux tubes, defining the body parts of MB, can become linked and knotted and can therefore form braids essential for topological quantum computation or its analog. Also 2-knots are possible and involve reconnection of magnetic flux tubes.

17.4.2 How bits and qubits could be represented?

How bits and qubits are represented? The Fock states of fundamental fermions define Boolean logic and in zero energy ontology (ZEO) the pairs of fermion states at opposite boundaries of causal diamond define analogs of Boolean statements.

- (a) A natural guess is that chemically represented genetic codons define 6-bit units. TGD predicts that genetic code also has dark counterparts. Dark proton sequences, consisting of dark proton triplets representing codons, would be associated with flux tubes parallel to DNA/RNA strand and even proteins. Dark genes would be sequences of n dark codons. The dark codons and hence dark genes are in principle independent of ordinary DNA and can be dynamical. They could transform to dark counterparts of ordinary DNA codons during communications and control based on energy resonance with ordinary codons. Dark codons would make possible self-simulation of the living matter.
- (b) Dark codons would be also realized as triplets of dark dark photons and would define dark memes. Icosa-tetrahedral representations of genetic code by codons realized as 3-chords defined by dark photon triplets. Dark codons defined by dark proton triplets. The proposal is that icoso-tetrahedral representation corresponds to icoso-tetrahedral tessellation of the hyperbolic space H^3 ([rb.gy/3u4pq](#)), which corresponds to mass shell in M^8 and to light-cone proper time constant hyperboloid in H .

There are an infinite number of tessellations but icoso-tetrahedral tessellation is very special. It is the only uniform honeycomb, which involves only Platonic solids such that their number is larger than one (tetrahedron, icosahedron, octahedron) [L144]. All faces are identical (triangles). There are also four regular tessellations involving only a single Platonic solid, which is icosahedron, dodecahedron or cube.

All 20 triangular faces can represent genetic codons in terms of quark associated with the vertices and genetic codons correspond to Hamiltonian cycles with symmetry groups Z_6 , Z_4 , and Z_2 . This gives 20+20+20 codons and tetrahedrons give the remaining codons. This tessellation might be more or less universal at the level of the MB and appear in very many physical systems, not only in biology. It could be associated even with the MBs assignable to computers.

Icosa-tetrahedral tessellation would also provide a seat for the representation of genes as sequences of dark proton triplets assignable to the faces of icosahedron and tetrahedron as in the icoso-tetrahedral representation of the genetic code. The connection of the icoso-tetrahedral tessellation with the detailed realization of the icoso-tetrahedral realization of the genetic code and with DNA double strand and its dark counterpart is discussed in [L144].

A further proposal is that the representations of the dark code are induced from to the MB from the icoso-tetrahedral tessellation so that genetic code could have also 2-D representations, say that assignable to the cell membrane, and even 3-D variants assignable to various parts of organism.

17.4.3 How communications and control could be realized?

The proposed model for the communication and control based on the genetic code allows also a mechanism of attention based on overlap of query and keywords.

- (a) Communications and control between dark genes, realized as dark proton sequences, could be realized using dark 3N-photon sequences generated in multi-cyclotron transitions of n codons (dark proton triplets) defining the gene. This kind of emission is not possible in the standard physics framework. Frequency scale modulation of dark Josephson radiation codes for the signal.
- (b) The receival of the signal would be based on 3N-resonance so that dark genes would serve as addresses much like in LISP. 3N-cyclotron resonance would occur in the receival of the signal by an identical gene and would generate a temporal sequence of resonances as analog of nerve pulse pattern.
- (c) Also partial 3N-resonance is possible for dark genes having some number of common codons. This could define a quantum physical analog for the overlap between query and keywords, and therefore an analog of the similarity metric. Query would be defined by a set of dark genes with N codons generating dark 3N-photon genes which would be received by a set of genes in partial 3N-resonance.

17.4.4 Could p-adic topologies provide a model for feature hierarchies?

In language models, the notion of distance function in the set of words as features is a key notion. The words, which appear together in the same context with high probability, are near to each other with respect to this distance.

The TGD inspired question is as follows. Grammatical rules represent important correlations appearing in the text. There are also correlations determined by the meaning of the words. Language models handle these correlations excellently. The distance determined by the meaning is only loosely related to the distance between the words. Could the grammatic correlations be coded by some simple, almost universal manner, based on some cognitive

model of language. It is probably unrealistic to assume that this distance relates in any predictable way to the physical distance between the words measured as the number of intervening words. There must be some other way to order the words. Labelling words by non-negative integers in such a way that two words which tend to appear together even if they are physically far away, is a suggestive approach. But which topology one should adopt in this set of integers. Real topology defined by a real distance function is the first guess but also p-adic topologies can be considered.

- (a) The TGD inspired view of cognition [K80] indeed relies on p-adic number fields, where p is prime [K78, K121, K122, K120] [L56, L55]. p-Adic topologies are defined by *ultrametric* norm $N(x) = d(x, 0)$ satisfying $d(x, y) \equiv N(x - y) \leq \max(d(x, z), d(y, z))$ whereas real norm satisfies $d(x, y) \leq d(x, z) + d(y, z)$. Locally, the p-adic topologies differ dramatically from real topology locally although one can map p-adics to reals continuously but not smoothly. For instance, the norms of integers x and $x + kp^n$, $n > 0$, are p-adically very near to each other for very large values of n whereas in real sense they are very far from each other. Spin glass energy landscape realizes ultrametric distance function and I have proposed that kinds of magnetic flux tube spaghetts give rise to quantum spin glasses [L113] having a fractal energy landscape with valleys within valleys. This provides spin glasses with a large representative capacity.
- (b) p-Adic numbers are not well-ordered and the p-adic norm defines only a rough ordering, which might be more natural than the real ordering which is perhaps too strict unless finite resolution is introduced. p-Adic integers have a natural hierarchy induced by the p-adic norm, which is very rough and for p-adic integers equals to a negative power of p . p-Adic numbers near to each other differ by a large positive power of p . Furthermore, p-adic numbers with a fixed p-adic norm equal to *negative* power of p decompose to a set of balls such that the balls are disjoint or coincide.

This would make p-adic numbers ideal for classification purposes and powers of p could define a hierarchy of features with highest level features corresponding to longest scales assignable to the largest value of the p-adic norm. The addition of finer features to a rough sketch would correspond to the addition of higher binary digits assignable to the finer features in the picture. The smaller the value of the p-adic norm, the less significant the feature would be concerning pattern recognition. The addition of features would correspond to addition of p-adic numbers and features with the same p-adic norm would be exclusive in order to make the binary expansion unique.

- (c) The ordering of the words is grammatically important and grammatical rules often require that the correlated words, say subject, verb and object, follow each other. Both subject, verb and object can have attributes so that the physical distance can vary. Consider the sentence "I admire him" as an example. In "I greatly admire him" "admire" has "greatly" as an attribute. This suggests a hierarchy of features: "greatly" would be a lower level feature as compared to "admire". Could attributes of the object correspond to higher binary digits than object?
- (d) What about p-adic topologies labelled by different primes (having also infinite number algebraic extensions induced by those of rationals to which one can assign evolutionary hierarchy). I have proposed that p-adic primes correspond to ramified primes for extensions of rationals [L126]. Ramified primes are divisors of the discriminant defined by the polynomial P determining a given region of space-time surface by $M^8 - M^4 \times CP_2$ duality [L90, L91, L154] mapping 4-D surfaces of M^8 determined by the roots of the polynomial in terms of holography to $H = M^4 \times CP_2$. P has integer coefficients. For a given extension, only a finite number of p-adic primes are possible.

On the basis of physical arguments, I have proposed that the coefficients of P must be smaller than the degree of P . This implies that for a given degree the number of acceptable polynomials is finite and ramified primes have an upper bound. In particular, for a given class of polynomials, say polynomials of a given degree, ramified primes have lower and upper bounds and could correspond to physically preferred p-adic primes. This could explain p-adic length scale hypothesis, inspired by p-adic mass

calculations [K69, K29] [L143], and stating that the p-adic primes near certain powers of 2 and possibly also other small integers are physically preferred.

Furthermore, the number of algebraic extensions having dimension smaller than given integer, would be finite, and the view about number theoretical evolution as an increase of the dimension of algebraic extension of rationals would emerge as an analog of second law and would become very predictive. Under this assumption also finite fields would emerge naturally besides other number fields as basic structures of TGD.

This picture inspires several questions. Could the algebraic extensions associated with various polynomials define different contexts or even different kinds of conscious entities at different levels of evolutionary hierarchy? If the p-adic topologies for a given algebraic extension correspond to ramified primes, could also ramified primes correspond to different contexts, which are not comparable? The word, or more generally feature, appearing in the context p_1 need not appear at all in the context p_2 and if it appears it has a different meaning. Could also written text generate mental images for which the corresponding space-time regions correspond to different p-adic topologies for given extension or even different algebraic extension.

There is an objection against this view. The proposed approach suggests that the generation of features should start from the long scales as an identification of the shape of the object. First comes the rough classification and then more detailed classifications. This is how we also experience pattern recognition. Attention is directed to gross features first and only after that the to smaller features. The neuroscience view however suggests bottom-up picture. Small features are identified first and the holistic picture emerges at highest levels of the hierarchy.

This view might be an illusion. In TGD, zero energy ontology allows the change of the arrow of time in "big" (ordinary) state function reductions and this could affect the situation dramatically. The time ordering for features assumed by the neuroscience picture could be replaced by an ordering of the scales of the causal diamonds associated with the feature as mental images. In the dynamics of quantum spin glasses [L113], the time evolution is indeed replaced with a scale evolution. This happens also in string models and the reason is that in TGD the conformal invariance of string models is replaced with its 4-D counterpart.

So: what could happen during sensory perception in the TGD Universe? Sensory perception would be basically building standardized mental images as an analog of pattern recognition. The sensory input would be very fuzzy but virtual sensory input would gradually lead to a standardized mental image as a kind of an artwork [L50].

- (a) The signals from the sensory organs would propagate from sensory organs as dark photons to the MBs having a layered onion-like structure [L50]. The primary function of the pulses need not be signalling. Rather, they establish connections between communication lines to make this possible. Very many feedback loops are possible since the signal velocity is the velocity of light.
- (b) Suppose that the MBs assignable to the brain are labelled by algebraic extensions of rational with dimension equal to h_{eff}/h_0 and each of them decomposes to a hierarchy labelled by the associated ramified primes. The larger the value of h_{eff} measuring the algebraic complexity, the more refined the cognitive representation. Different algebraic extensions could correspond to different kinds of conscious entities. The mental images of a given conscious entity are assumed to correspond to sub-selves. They could correspond to lower levels of algebraic complexity and to a smaller value of h_{eff} . They could also correspond to small ramified primes for a given algebraic extension.
- (c) Several ramified primes p assignable to a given extension could be involved and define different contexts. The largest ramified prime p would correspond to the largest p-adic scale and could correspond to the largest features for a given algebraic

extension. The powers of p in the pinary expansion could correspond to higher level features as details or attributes.

The large scale part of the virtual sensory input to the sensory organs would correspond to the largest p-adic prime p . The first virtual sensory input would correspond to a p-adic number $m_0 < p$ with a p-adic norm equal to one. This would induce as a reaction an improved sensory input to MB as dark photons. If the pattern recognition cognition process converges, this sensory input induces a more refined virtual sensory input characterized by the p-adic number $m_0 + m_1 p$. This sensory feedback loop would give rise to standardized mental images. The integer m_1 would not code for a single feature but for a collection of features.

- (d) Virtual sensory input should not be confused with the feedback inducing change of the parameters h in learning. The counterpart of h would modify various synaptic contacts and their analogies involved with the process. The convergence of the procedure to some standardized mental image however suggests the analog for the minimization of a loss function by gradient dynamics. The loss function could correspond to a height function in the spin glass energy landscape [?]. The process itself could be an analog of annealing allowing to avoid getting stuck into a local minimum. The virtual sensory could play the role of feeding energy to the system so that it gets out from the fake minimum.
- (e) The above mentioned paradox could be only apparent if the processing of features in various scales occurs in parallel. If gross features correspond to the layers of the MB with a larger size scale, the time needed to build the virtual sensory image for large scale features would be longer than for small scale features. Small scale features would stabilize first. The order of the structural layers of the brain would correspond to increasing size of the layer of MB.
- (f) Note that in the case of extension of rationals, integers m_i would be algebraic integers of the extension so that the features would be n-dimensional in an algebraic sense.

What learning could correspond in this picture? Zero energy ontology predicts that the arrow of time changes in "big" (ordinary) statefunction reductions (BSFRs). For "small" SFRs (SSFRs) this does not take place and the sequence of SSFRs define conscious entity, self. BSFR corresponds to the "death" of the conscious entity and also sleep could correspond to BSFR. The arrow of time can change also temporarily and our conscious experience indeed contains gaps. This temporary change of the arrow of time would change zero energy state as a superposition of space-time surfaces analogous to almost deterministic Bohr orbits and defining a quantum goal for the system.

Maybe learning by trial and error b pairs of BSFRs leading to a temporary change of the arrow of time and demonstrating that certain BSFRs are not favourable. We might even learn moral rules and ethics ("Try to increase quantum coherence" as a basic ethical rule) by this kind of intentional trial and error process. Maybe this could also occur for computers with life-like properties.

17.4.5 An analog of a multi-perceptron model related to holography in TGD

TGD suggests a non-trivial example, which might have some relevance some day.

- (a) In TGD, holography assigns to a given 3-surface X^3 an almost unique 4-D minimal surface X^4 in 8-D space $H = M^4 \times CP_2$. X^4 can have lower-D singularities. X^4 is defined by a vanishing of 4 functions g_k of H coordinates for which TGD suggests a general form.
- (b) The parameters determining g_k must be determined from the a priori knowledge of the 3-surface X^3 , which can be chosen to correspond to a constant value of a suitably

chosen time coordinate t of M^4 . X^3 takes the role of a feature which the system must learn to detect by varying the parameters appearing in the functions g_k .

- (c) The inputs to perceptron would be the 8 coordinates of H with t fixed. The arguments y_k of the outputs are the 4 functions g_k , which must vanish at X^4 . The response functions $f_k(y_k = g_k)$ must vanish at X^3 . The feedback modifies the parameters appearing in the functions g_k and the system should find the parameter values producing X^3 .
- (d) Holography means that, apart from the failure of complete determinism, the system learns also to predict the behavior of the system as "Bohr orbit" $X^4(X^3)$ of X^3 .

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Chapter i

Appendix

A-1 Introduction

Originally this appendix was meant to be a purely technical summary of basic facts but in its recent form it tries to briefly summarize those basic visions about TGD which I dare to regard stabilized. I have added illustrations making it easier to build mental images about what is involved and represented briefly the key arguments. This chapter is hoped to help the reader to get fast grasp about the concepts of TGD.

The basic properties of embedding space and related spaces are discussed and the relationship of CP_2 to the standard model is summarized. The basic vision is simple: the geometry of the embedding space $H = M^4 \times CP_2$ geometrizes standard model symmetries and quantum numbers. The assumption that space-time surfaces are basic objects, brings in dynamics as dynamics of 3-D surfaces based on the induced geometry. Second quantization of free spinor fields of H induces quantization at the level of H , which means a dramatic simplification.

The notions of induction of metric and spinor connection, and of spinor structure are discussed. Many-sheeted space-time and related notions such as topological field quantization and the relationship many-sheeted space-time to that of GRT space-time are discussed as well as the recent view about induced spinor fields and the emergence of fermionic strings. Also the relationship to string models is discussed briefly.

Various topics related to p-adic numbers are summarized with a brief definition of p-adic manifold and the idea about generalization of the number concept by gluing real and p-adic number fields to a larger book like structure analogous to adèle [L55, L56]. In the recent view of quantum TGD [L142], both notions reduce to physics as number theory vision, which relies on $M^8 - H$ duality [L90, L91] and is complementary to the physics as geometry vision.

Zero energy ontology (ZEO) [L89] [K146] has become a central part of quantum TGD and leads to a TGD inspired theory of consciousness as a generalization of quantum measurement theory having quantum biology as an application. Also these aspects of TGD are briefly discussed.

A-2 Embedding space $M^4 \times CP_2$

Space-times are regarded as 4-surfaces in $H = M^4 \times CP_2$ the Cartesian product of empty Minkowski space - the space-time of special relativity - and compact 4-D space CP_2 with size scale of order 10^4 Planck lengths. One can say that embedding space is obtained by replacing each point m of empty Minkowski space with 4-D tiny CP_2 . The space-time of general relativity is replaced by a 4-D surface in H which has very complex topology. The notion of many-sheeted space-time gives an idea about what is involved.

Fig. 1. Embedding space $H = M^4 \times CP_2$ as Cartesian product of Minkowski space M^4 and complex projective space CP_2 . <http://tgdtheory.fi/appfigures/Hoo.jpg>

Denote by M_+^4 and M_-^4 the future and past directed lightcones of M^4 . Denote their intersection, which is not unique, by CD. In zero energy ontology (ZEO) [L89, L112] [K146] causal diamond (CD) is defined as cartesian product $CD \times CP_2$. Often I use CD to refer just to $CD \times CP_2$ since CP_2 factor is relevant from the point of view of ZEO.

Fig. 2. Future and past light-cones M_+^4 and M_-^4 . Causal diamonds (CD) are defined as their intersections. <http://tgdtheory.fi/appfigures/futurepast.jpg>

Fig. 3. Causal diamond (CD) is highly analogous to Penrose diagram but simpler. <http://tgdtheory.fi/appfigures/penrose.jpg>

A rather recent discovery was that CP_2 is the only compact 4-manifold with Euclidian signature of metric allowing twistor space with Kähler structure. M^4 is in turn is the only 4-D space with Minkowskian signature of metric allowing twistor space with Kähler structure [A19] so that $H = M^4 \times CP_2$ is twistorially unique.

One can loosely say that quantum states in a given sector of “world of classical worlds” (WCW) are superpositions of space-time surfaces inside CDs and that positive and negative energy parts of zero energy states are localized and past and future boundaries of CDs. CDs form a hierarchy. One can have CDs within CDs and CDs can also overlap. The size of CD is characterized by the proper time distance between its two tips. One can perform both translations and also Lorentz boosts of CD leaving either boundary invariant. Therefore one can assign to CDs a moduli space and speak about wave function in this moduli space.

In number theoretic approach it is natural to restrict the allowed Lorentz boosts to some discrete subgroup of Lorentz group and also the distances between the tips of CDs to multiples of CP_2 radius defined by the length of its geodesic. Therefore the moduli space of CDs discretizes. The quantization of cosmic recession velocities for which there are indications, could relate to this quantization.

A-2.1 Basic facts about CP_2

CP_2 as a four-manifold is very special. The following arguments demonstrate that it codes for the symmetries of standard models via its isometries and holonomies.

CP_2 as a manifold

CP_2 , the complex projective space of two complex dimensions, is obtained by identifying the points of complex 3-space C^3 under the projective equivalence

$$(z^1, z^2, z^3) \equiv \lambda(z^1, z^2, z^3) . \quad (\text{A-2.1})$$

Here λ is any non-zero complex number. Note that CP_2 can be also regarded as the coset space $SU(3)/U(2)$. The pair z^i/z^j for fixed j and $z^i \neq 0$ defines a complex coordinate chart for CP_2 . As j runs from 1 to 3 one obtains an atlas of three coordinate charts covering CP_2 , the charts being holomorphically related to each other (e.g. CP_2 is a complex manifold). The points $z^3 \neq 0$ form a subset of CP_2 homeomorphic to R^4 and the points with $z^3 = 0$ a set homeomorphic to S^2 . Therefore CP_2 is obtained by “adding the 2-sphere at infinity to R^4 ”.

Besides the standard complex coordinates $\xi^i = z^i/z^3$, $i = 1, 2$ the coordinates of Eguchi and Freund [A14] will be used and their relation to the complex coordinates is given by

$$\begin{aligned} \xi^1 &= z + it , \\ \xi^2 &= x + iy . \end{aligned} \quad (\text{A-2.2})$$

These are related to the “spherical coordinates” via the equations

$$\begin{aligned}\xi^1 &= r \exp(i \frac{(\Psi + \Phi)}{2}) \cos(\frac{\Theta}{2}) , \\ \xi^2 &= r \exp(i \frac{(\Psi - \Phi)}{2}) \sin(\frac{\Theta}{2}) .\end{aligned}\tag{A-2.3}$$

The ranges of the variables r, Θ, Φ, Ψ are $[0, \infty], [0, \pi], [0, 4\pi], [0, 2\pi]$ respectively.

Considered as a real four-manifold CP_2 is compact and simply connected, with Euler number 3, Pontryagin number 3 and second $b = 1$.

Fig. 4. CP_2 as manifold. <http://tgdtheory.fi/appfigures/cp2.jpg>

Metric and Kähler structure of CP_2

In order to obtain a natural metric for CP_2 , observe that CP_2 can be thought of as a set of the orbits of the isometries $z^i \rightarrow \exp(i\alpha)z^i$ on the sphere S^5 : $\sum z^i \bar{z}^i = R^2$. The metric of CP_2 is obtained by projecting the metric of S^5 orthogonally to the orbits of the isometries. Therefore the distance between the points of CP_2 is that between the representative orbits on S^5 .

The line element has the following form in the complex coordinates

$$ds^2 = g_{a\bar{b}} d\xi^a d\bar{\xi}^b ,\tag{A-2.4}$$

where the Hermitian, in fact Kähler metric $g_{a\bar{b}}$ is defined by

$$g_{a\bar{b}} = R^2 \partial_a \partial_{\bar{b}} K ,\tag{A-2.5}$$

where the function K , Kähler function, is defined as

$$\begin{aligned}K &= \log(F) , \\ F &= 1 + r^2 .\end{aligned}\tag{A-2.6}$$

The Kähler function for S^2 has the same form. It gives the S^2 metric $dzd\bar{z}/(1+r^2)^2$ related to its standard form in spherical coordinates by the coordinate transformation $(r, \phi) = (\tan(\theta/2), \phi)$.

The representation of the CP_2 metric is deducible from S^5 metric is obtained by putting the angle coordinate of a geodesic sphere constant in it and is given

$$\frac{ds^2}{R^2} = \frac{(dr^2 + r^2 \sigma_3^2)}{F^2} + \frac{r^2(\sigma_1^2 + \sigma_2^2)}{F} ,\tag{A-2.7}$$

where the quantities σ_i are defined as

$$\begin{aligned}
r^2 \sigma_1 &= \text{Im}(\xi^1 d\xi^2 - \xi^2 d\xi^1) , \\
r^2 \sigma_2 &= -\text{Re}(\xi^1 d\xi^2 - \xi^2 d\xi^1) , \\
r^2 \sigma_3 &= -\text{Im}(\xi^1 d\bar{\xi}^1 + \xi^2 d\bar{\xi}^2) .
\end{aligned} \tag{A-2.8}$$

R denotes the radius of the geodesic circle of CP_2 . The vierbein forms, which satisfy the defining relation

$$s_{kl} = R^2 \sum_A e_k^A e_l^A , \tag{A-2.9}$$

are given by

$$\begin{aligned}
e^0 &= \frac{dr}{F} , & e^1 &= \frac{r\sigma_1}{\sqrt{F}} , \\
e^2 &= \frac{r\sigma_2}{\sqrt{F}} , & e^3 &= \frac{r\sigma_3}{F} .
\end{aligned} \tag{A-2.10}$$

The explicit representations of vierbein vectors are given by

$$\begin{aligned}
e^0 &= \frac{dr}{F} , & e^1 &= \frac{r(\sin\Theta \cos\Psi d\Phi + \sin\Psi d\Theta)}{2\sqrt{F}} , \\
e^2 &= \frac{r(\sin\Theta \sin\Psi d\Phi - \cos\Psi d\Theta)}{2\sqrt{F}} , & e^3 &= \frac{r(d\Psi + \cos\Theta d\Phi)}{2F} .
\end{aligned} \tag{A-2.11}$$

The explicit representation of the line element is given by the expression

$$ds^2/R^2 = \frac{dr^2}{F^2} + \frac{r^2}{4F^2}(d\Psi + \cos\Theta d\Phi)^2 + \frac{r^2}{4F}(d\Theta^2 + \sin^2\Theta d\Phi^2) . \tag{A-2.12}$$

From this expression one finds that at coordinate infinity $r = \infty$ line element reduces to $\frac{r^2}{4F}(d\Theta^2 + \sin^2\Theta d\Phi^2)$ of S^2 meaning that 3-sphere degenerates metrically to 2-sphere and one can say that CP_2 is obtained by adding to R^4 a 2-sphere at infinity.

The vierbein connection satisfying the defining relation

$$de^A = -V_B^A \wedge e^B , \tag{A-2.13}$$

is given by

$$\begin{aligned}
V_{01} &= -\frac{e^1}{r} , & V_{23} &= \frac{e^1}{r} , \\
V_{02} &= -\frac{e^2}{r} , & V_{31} &= \frac{e^2}{r} , \\
V_{03} &= (r - \frac{1}{r})e^3 , & V_{12} &= (2r + \frac{1}{r})e^3 .
\end{aligned} \tag{A-2.14}$$

The representation of the covariantly constant curvature tensor is given by

$$\begin{aligned}
R_{01} &= e^0 \wedge e^1 - e^2 \wedge e^3, & R_{23} &= e^0 \wedge e^1 - e^2 \wedge e^3, \\
R_{02} &= e^0 \wedge e^2 - e^3 \wedge e^1, & R_{31} &= -e^0 \wedge e^2 + e^3 \wedge e^1, \\
R_{03} &= 4e^0 \wedge e^3 + 2e^1 \wedge e^2, & R_{12} &= 2e^0 \wedge e^3 + 4e^1 \wedge e^2.
\end{aligned} \tag{A-2.15}$$

Metric defines a real, covariantly constant, and therefore closed 2-form J

$$J = -is_{a\bar{b}} d\xi^a d\bar{\xi}^b, \tag{A-2.16}$$

the so called Kähler form. Kähler form J defines in CP_2 a symplectic structure because it satisfies the condition

$$J^k_r J^{rl} = -s^{kl}. \tag{A-2.17}$$

The condition states that J and g give representations of real unit and imaginary units related by the formula $i^2 = -1$.

Kähler form is expressible locally in terms of Kähler gauge potential

$$J = dB, \tag{A-2.18}$$

where B is the so called Kähler potential, which is not defined globally since J describes homological magnetic monopole.

$dJ = dB = 0$ gives the topological half of Maxwell equations (vanishing of magnetic charges and Faraday's induction law) and self-duality $*J = J$ reduces the remaining equations to $dJ = 0$. Hence the Kähler form can be regarded as a curvature form of a $U(1)$ gauge potential B carrying a magnetic charge of unit $1/2g$ (g denotes the gauge coupling).

The magnetic flux of J through a 2-surface in CP_2 is proportional to its homology equivalence class, which is integer valued. The explicit representations of J and B are given by

$$\begin{aligned}
B &= 2re^3, \\
J &= 2(e^0 \wedge e^3 + e^1 \wedge e^2) = \frac{r}{F^2} dr \wedge (d\Psi + \cos\Theta d\Phi) + \frac{r^2}{2F} \sin\Theta d\Theta \wedge d\Phi.
\end{aligned} \tag{A-2.19}$$

The vierbein curvature form and Kähler form are covariantly constant and have in the complex coordinates only components of type $(1, 1)$.

Useful coordinates for CP_2 are the so called canonical (or symplectic or Darboux) coordinates in which the Kähler potential and Kähler form have very simple expressions

$$\begin{aligned}
B &= \sum_{k=1,2} P_k dQ_k, \\
J &= \sum_{k=1,2} dP_k \wedge dQ_k.
\end{aligned} \tag{A-2.20}$$

The relationship of the canonical coordinates to the “spherical” coordinates is given by the equations

$$\begin{aligned} P_1 &= -\frac{1}{1+r^2} , \\ P_2 &= -\frac{r^2 \cos \Theta}{2(1+r^2)} , \\ Q_1 &= \Psi , \\ Q_2 &= \Phi . \end{aligned} \tag{A-2.21}$$

Spinors In CP_2

CP_2 doesn't allow spinor structure in the conventional sense [A11]. However, the coupling of the spinors to a half odd multiple of the Kähler potential leads to a respectable spinor structure. Because the delicacies associated with the spinor structure of CP_2 play a fundamental role in TGD, the arguments of Hawking are repeated here.

To see how the space can fail to have an ordinary spinor structure consider the parallel transport of the vierbein in a simply connected space M . The parallel propagation around a closed curve with a base point x leads to a rotated vierbein at x : $e^A = R_B^A e^B$ and one can associate to each closed path an element of $SO(4)$.

Consider now a one-parameter family of closed curves $\gamma(v) : v \in (0, 1)$ with the same base point x and $\gamma(0)$ and $\gamma(1)$ trivial paths. Clearly these paths define a sphere S^2 in M and the element $R_B^A(v)$ defines a closed path in $SO(4)$. When the sphere S^2 is contractible to a point e.g., homologically trivial, the path in $SO(4)$ is also contractible to a point and therefore represents a trivial element of the homotopy group $\Pi_1(SO(4)) = Z_2$.

For a homologically nontrivial 2-surface S^2 the associated path in $SO(4)$ can be homotopically nontrivial and therefore corresponds to a nonclosed path in the covering group $\text{Spin}(4)$ (leading from the matrix 1 to -1 in the matrix representation). Assume this is the case.

Assume now that the space allows spinor structure. Then one can parallel propagate also spinors and by the above construction associate a closed path of $\text{Spin}(4)$ to the surface S^2 . Now, however this path corresponds to a lift of the corresponding $SO(4)$ path and cannot be closed. Thus one ends up with a contradiction.

From the preceding argument it is clear that one could compensate the non-allowed -1 -factor associated with the parallel transport of the spinor around the sphere S^2 by coupling it to a gauge potential in such a way that in the parallel transport the gauge potential introduces a compensating -1 -factor. For a $U(1)$ gauge potential this factor is given by the exponential $\exp(i2\Phi)$, where Φ is the magnetic flux through the surface. This factor has the value -1 provided the $U(1)$ potential carries half odd multiple of Dirac charge $1/2g$. In case of CP_2 the required gauge potential is half odd multiple of the Kähler potential B defined previously. In the case of $M^4 \times CP_2$ one can in addition couple the spinor components with different chiralities independently to an odd multiple of $B/2$.

Geodesic sub-manifolds of CP_2

Geodesic sub-manifolds are defined as sub-manifolds having common geodesic lines with the embedding space. As a consequence the second fundamental form of the geodesic manifold vanishes, which means that the tangent vectors h_α^k (understood as vectors of H) are covariantly constant quantities with respect to the covariant derivative taking into account that the tangent vectors are vectors both with respect to H and X^4 .

In [A23] a general characterization of the geodesic sub-manifolds for an arbitrary symmetric space G/H is given. Geodesic sub-manifolds are in 1-1-correspondence with the so called Lie triple systems of the Lie-algebra g of the group G . The Lie triple system t is defined as a subspace of g characterized by the closedness property with respect to double commutation

$$[X, [Y, Z]] \in t \text{ for } X, Y, Z \in t . \quad (\text{A-2.22})$$

$SU(3)$ allows, besides geodesic lines, two nonequivalent (not isometry related) geodesic spheres. This is understood by observing that $SU(3)$ allows two nonequivalent $SU(2)$ algebras corresponding to subgroups $SO(3)$ (orthogonal 3×3 matrices) and the usual isospin group $SU(2)$. By taking any subset of two generators from these algebras, one obtains a Lie triple system and by exponentiating this system, one obtains a 2-dimensional geodesic sub-manifold of CP_2 .

Standard representatives for the geodesic spheres of CP_2 are given by the equations

$$S_I^2 : \xi^1 = \bar{\xi}^2 \text{ or equivalently } (\Theta = \pi/2, \Psi = 0) ,$$

$$S_{II}^2 : \xi^1 = \xi^2 \text{ or equivalently } (\Theta = \pi/2, \Phi = 0) .$$

The non-equivalence of these sub-manifolds is clear from the fact that isometries act as holomorphic transformations in CP_2 . The vanishing of the second fundamental form is also easy to verify. The first geodesic manifold is homologically trivial: in fact, the induced Kähler form vanishes identically for S_I^2 . S_{II}^2 is homologically nontrivial and the flux of the Kähler form gives its homology equivalence class.

A-2.2 CP_2 geometry and Standard Model symmetries

Identification of the electro-weak couplings

The delicacies of the spinor structure of CP_2 make it a unique candidate for space S . First, the coupling of the spinors to the $U(1)$ gauge potential defined by the Kähler structure provides the missing $U(1)$ factor in the gauge group. Secondly, it is possible to couple different H -chiralities independently to a half odd multiple of the Kähler potential. Thus the hopes of obtaining a correct spectrum for the electromagnetic charge are considerable. In the following it will be demonstrated that the couplings of the induced spinor connection are indeed those of the GWS model [B16] and in particular that the right handed neutrinos decouple completely from the electro-weak interactions.

To begin with, recall that the space H allows to define three different chiralities for spinors. Spinors with fixed H -chirality $e = \pm 1$, CP_2 -chirality l, r and M^4 -chirality L, R are defined by the condition

$$\begin{aligned} \Gamma\Psi &= e\Psi , \\ e &= \pm 1 , \end{aligned} \quad (\text{A-2.23})$$

where Γ denotes the matrix $\Gamma_9 = \gamma_5 \otimes \gamma_5$, $1 \otimes \gamma_5$ and $\gamma_5 \otimes 1$ respectively. Clearly, for a fixed H -chirality CP_2 - and M^4 -chiralities are correlated.

The spinors with H -chirality $e = \pm 1$ can be identified as quark and lepton like spinors respectively. The separate conservation of baryon and lepton numbers can be understood as a consequence of generalized chiral invariance if this identification is accepted. For the spinors with a definite H -chirality one can identify the vielbein group of CP_2 as the electro-weak group: $SO(4)$ having as its covering group $SU(2)_L \times SU(2)_R$.

The covariant derivatives are defined by the spinorial connection

$$A = V + \frac{B}{2}(n_+ 1_+ + n_- 1_-) . \quad (\text{A-2.24})$$

Here V and B denote the projections of the vielbein and Kähler gauge potentials respectively and $1_{+(-)}$ projects to the spinor H -chirality $+(-)$. The integers n_{\pm} are odd from the requirement of a respectable spinor structure.

The explicit representation of the vielbein connection V and of B are given by the equations

$$\begin{aligned} V_{01} &= -\frac{e^1}{r} , & V_{23} &= \frac{e^1}{r} , \\ V_{02} &= -\frac{e^2}{r} , & V_{31} &= \frac{e^2}{r} , \\ V_{03} &= (r - \frac{1}{r})e^3 , & V_{12} &= (2r + \frac{1}{r})e^3 , \end{aligned} \quad (\text{A-2.25})$$

and

$$B = 2re^3 , \quad (\text{A-2.26})$$

respectively. The explicit representation of the vielbein is not needed here.

Let us first show that the charged part of the spinor connection couples purely left handedly. Identifying Σ_3^0 and Σ_2^1 as the diagonal (neutral) Lie-algebra generators of $SO(4)$, one finds that the charged part of the spinor connection is given by

$$A_{ch} = 2V_{23}I_L^1 + 2V_{13}I_L^2 , \quad (\text{A-2.27})$$

where one have defined

$$\begin{aligned} I_L^1 &= \frac{(\Sigma_{01} - \Sigma_{23})}{2} , \\ I_L^2 &= \frac{(\Sigma_{02} - \Sigma_{13})}{2} . \end{aligned} \quad (\text{A-2.28})$$

A_{ch} is clearly left handed so that one can perform the identification of the gauge potential as

$$W^{\pm} = \frac{2(e^1 \pm ie^2)}{r} , \quad (\text{A-2.29})$$

where W^{\pm} denotes the charged intermediate vector boson.

The covariantly constant curvature tensor is given by

$$\begin{aligned} R_{01} &= -R_{23} = e^0 \wedge e^1 - e^2 \wedge e^3 , \\ R_{02} &= -R_{31} = e^0 \wedge e^2 - e^3 \wedge e^1 , \\ R_{03} &= 4e^0 \wedge e^3 + 2e^1 \wedge e^2 , \\ R_{12} &= 2e^0 \wedge e^3 + 4e^1 \wedge e^2 . \end{aligned} \quad (\text{A-2.30})$$

The charged part of the curvature tensor is left handed.

This is to be compared with the Weyl tensor, which defines a representation of quaternionic imaginary units.

$$\begin{aligned}
W_{03} = W_{12} &\equiv 2I_3 = 2(e^0 \wedge e^3 + e^1 \wedge e^2) , \\
W_{01} = W_{23} &\equiv I_1 = -e^0 \wedge e^1 - e^2 \wedge e^3 , \\
W_{02} = W_{31} &\equiv I_2 = -e^0 \wedge e^2 - e^3 \wedge e^1 .
\end{aligned} \tag{A-2.31}$$

The charged part of the Weyl tensor is right-handed and that the relative sign of the two terms in the curvature tensor and Weyl tensor are opposite.

Consider next the identification of the neutral gauge bosons γ and Z^0 as appropriate linear combinations of the two functionally independent quantities

$$\begin{aligned}
X &= re^3 , \\
Y &= \frac{e^3}{r} ,
\end{aligned} \tag{A-2.32}$$

appearing in the neutral part of the spinor connection. We show first that the mere requirement that photon couples vectorially implies the basic coupling structure of the GWS model leaving only the value of Weinberg angle undetermined.

To begin with let us define

$$\begin{aligned}
\bar{\gamma} &= aX + bY , \\
\bar{Z}^0 &= cX + dY ,
\end{aligned} \tag{A-2.33}$$

where the normalization condition

$$ad - bc = 1 ,$$

is satisfied. The physical fields γ and Z^0 are related to $\bar{\gamma}$ and \bar{Z}^0 by simple normalization factors.

Expressing the neutral part of the spinor connection in term of these fields one obtains

$$\begin{aligned}
A_{nc} &= [(c+d)2\Sigma_{03} + (2d-c)2\Sigma_{12} + d(n_+1_+ + n_-1_-)]\bar{\gamma} \\
&+ [(a-b)2\Sigma_{03} + (a-2b)2\Sigma_{12} - b(n_+1_+ + n_-1_-)]\bar{Z}^0 .
\end{aligned} \tag{A-2.34}$$

Identifying Σ_{12} and $\Sigma_{03} = 1 \times \gamma_5 \Sigma_{12}$ as vectorial and axial Lie-algebra generators, respectively, the requirement that γ couples vectorially leads to the condition

$$c = -d . \tag{A-2.35}$$

Using this result plus previous equations, one obtains for the neutral part of the connection the expression

$$A_{nc} = \gamma Q_{em} + Z^0 (I_L^3 - \sin^2 \theta_W Q_{em}) . \tag{A-2.36}$$

Here the electromagnetic charge Q_{em} and the weak isospin are defined by

$$\begin{aligned}
Q_{em} &= \Sigma^{12} + \frac{(n_+1_+ + n_-1_-)}{6} , \\
I_L^3 &= \frac{(\Sigma^{12} - \Sigma^{03})}{2} .
\end{aligned} \tag{A-2.37}$$

The fields γ and Z^0 are defined via the relations

$$\begin{aligned}
\gamma &= 6d\bar{\gamma} = \frac{6}{(a+b)}(aX + bY) , \\
Z^0 &= 4(a+b)\bar{Z}^0 = 4(X - Y) .
\end{aligned} \tag{A-2.38}$$

The value of the Weinberg angle is given by

$$\sin^2\theta_W = \frac{3b}{2(a+b)} , \tag{A-2.39}$$

and is not fixed completely. Observe that right handed neutrinos decouple completely from the electro-weak interactions.

The determination of the value of the Weinberg angle is a dynamical problem. The original approach was based on the assumption that it makes sense to talk about electroweak action defined at fundamental level and introduce a symmetry breaking by adding an additional term proportional to Kähler action. The recent view is that Kähler action plus volume term defines the fundamental action.

The Weinberg angle is completely fixed if one requires that the electroweak action contains no cross term of type γZ^0 . This leads to a definite value for the Weinberg angle.

One can however add a symmetry breaking term proportional to Kähler action and this changes the value of the Weinberg angle. As a matter fact, color gauge action identifying color gauge field as proportional to $H^A J_{\alpha\beta}$ is proportional to Kähler action. A possible interpretation would be as a sum of electroweak and color gauge interactions.

To evaluate the value of the Weinberg angle one can express the neutral part F_{nc} of the induced gauge field as

$$F_{nc} = 2R_{03}\Sigma^{03} + 2R_{12}\Sigma^{12} + J(n_+1_+ + n_-1_-) , \tag{A-2.40}$$

where one has

$$\begin{aligned}
R_{03} &= 2(2e^0 \wedge e^3 + e^1 \wedge e^2) , \\
R_{12} &= 2(e^0 \wedge e^3 + 2e^1 \wedge e^2) , \\
J &= 2(e^0 \wedge e^3 + e^1 \wedge e^2) ,
\end{aligned} \tag{A-2.41}$$

in terms of the fields γ and Z^0 (photon and Z - boson)

$$F_{nc} = \gamma Q_{em} + Z^0(I_L^3 - \sin^2\theta_W Q_{em}) . \tag{A-2.42}$$

Evaluating the expressions above, one obtains for γ and Z^0 the expressions

$$\begin{aligned}\gamma &= 3J - \sin^2\theta_W R_{12} , \\ Z^0 &= 2R_{03} .\end{aligned}\tag{A-2.43}$$

For the Kähler field one obtains

$$J = \frac{1}{3}(\gamma + \sin^2\theta_W Z^0) .\tag{A-2.44}$$

Expressing the neutral part of the symmetry broken YM action

$$\begin{aligned}L_{ew} &= L_{sym} + f J^{\alpha\beta} J_{\alpha\beta} , \\ L_{sym} &= \frac{1}{4g^2} \text{Tr}(F^{\alpha\beta} F_{\alpha\beta}) ,\end{aligned}\tag{A-2.45}$$

where the trace is taken in spinor representation, in terms of γ and Z^0 one obtains for the coefficient X of the γZ^0 cross term (this coefficient must vanish) the expression

$$\begin{aligned}X &= -\frac{K}{2g^2} + \frac{fp}{18} , \\ K &= \text{Tr} [Q_{em}(I_L^3 - \sin^2\theta_W Q_{em})] ,\end{aligned}\tag{A-2.46}$$

This parameter can be calculated by substituting the values of quark and lepton charges and weak isospins.

In the general case the value of the coefficient K is given by

$$K = \sum_i \left[-\frac{(18 + 2n_i^2)\sin^2\theta_W}{9} \right] ,\tag{A-2.47}$$

where the sum is over the spinor chiralities, which appear as elementary fermions and n_i is the integer describing the coupling of the spinor field to the Kähler potential. The cross term vanishes provided the value of the Weinberg angle is given by

$$\sin^2\theta_W = \frac{9 \sum_i 1}{(fg^2 + 2 \sum_i (18 + n_i^2))} .\tag{A-2.48}$$

In the scenario where both leptons and quarks are elementary fermions the value of the Weinberg angle is given by

$$\sin^2\theta_W = \frac{9}{(\frac{fg^2}{2} + 28)} .\tag{A-2.49}$$

The bare value of the Weinberg angle is 9/28 in this scenario, which is not far from the typical value 9/24 of GUTs at high energies [B6]. The experimental value at the scale

length scale of the electron can be deduced from the ratio of W and Z boson masses as $\sin^2\theta_W = 1 - (m_W/m_Z)^2 \simeq .22290$. This ratio and also the weak boson masses depend on the length scale.

If one interprets the additional term proportional to J as color action, one could perhaps interpret the value of Weinberg angle as expressing a connection between strong and weak coupling constant evolution. The limit $f \rightarrow 0$ should correspond to an infinite value of color coupling strength and at this limit one would have $\sin^2\theta_W = \frac{9}{28}$ for $f/g^2 \rightarrow 0$. This does not make sense since the Weinberg angle is in the standard model much smaller in QCD scale Λ corresponding roughly to pion mass scale. The Weinberg angle is in principle predicted by the p-adic coupling constant evolution fixed by the number theoretical vision of TGD.

One could however have a sum of electroweak action, correction terms changing the value of Weinberg angle, and color action and coupling constant evolution could be understood in terms of the coupling parameters involved.

Electroweak symmetry breaking

One of the hardest challenges in the development of the TGD based view of weak symmetry breaking was the fact that classical field equations allow space-time surfaces with finite but arbitrarily large size. For a fixed space-time surface, the induced gauge fields, including classical weak fields, are long ranged. On the other hand, the large mass for weak bosons would require a short correlation length. How can one understand this together with the fact that a photon has a long correlation length?

In zero energy ontology quantum states are superpositions of space-time surfaces as analogs of almost unique Bohr orbits of particles identified as 3-D surfaces. For some reason the superposition should be such that the quantum averages of weak gauge boson fields vanish below the weak scale whereas the quantum average of electromagnetic fields is non-vanishing. This is indeed the case.

- (a) The supersymplectic symmetries form isometries of the world of classical worlds (WCW) and they act in CP_2 degrees of freedom as symplectic transformations leaving the CP_2 symplectic form J invariant and therefore also its contribution to the electromagnetic field since this part is the same for all space-time surfaces in the superposition of space-time surfaces as a representation of supersymplectic isometry group (as a special case a representation of color group).
- (b) In TGD, color and electroweak symmetries acting as holonomies are not independent and for the $SU(2)_L$ part of induced spinor connection the symplectic transformations induces $SU(2)_L \times U(1)_R$ gauge transformation. This suggests that the quantum expectations of the induced weak fields over the space-time surfaces vanish above the quantum coherence scale. The averages of W and of the left handed part of Z^0 should therefore vanish.
- (c) $\langle Z^0 \rangle$ should vanish. For $U(1)_R$ part of Z^0 , the action of gauge transformation is trivial in gauge theory. Now however the space-time surface changes under symplectic transformations and this could make the average of the right-handed part of Z^0 vanishing. The vanishing of the average of the axial part of the Z^0 is suggested by the partially conserved axial current hypothesis.

One can formulate this picture quantitatively.

- (a) The electromagnetic field [L157] contains, besides the induced Kähler form, also the induced curvature form R_{12} , which couples vectorially. Conserved vector current hypothesis suggests that the average of R_{12} is non-vanishing. One can express the neutral part of the induced gauge field in terms of induced spinor curvature and Kähler form J as

$$\begin{aligned}
R_{03} &= 2(2e^0 \wedge e^3 + e^1 \wedge e^2) = J + 2e^0 \wedge e^3 , \\
J &= 2(e^0 \wedge e^3 + e^1 \wedge e^2) , \\
R_{12} &= 2(e^0 \wedge e^3 + 2e^1 \wedge e^2) = 3J - 2e^0 \wedge e^3 ,
\end{aligned} \tag{A-2.50}$$

(b) The induced fields γ and Z^0 (photon and Z - boson) can be expressed as

$$\begin{aligned}
\gamma &= 3J - \sin^2 \theta_W R_{12} , \\
Z^0 &= 2R_{03} = 2(J + 2e^0 \wedge e^3)
\end{aligned} \tag{A-2.51}$$

$$per. \tag{A-2.52}$$

The condition $\langle Z^0 \rangle = 0$ gives $2\langle e^0 \wedge e^3 \rangle = -2J$ and this in turn gives $\langle R_{12} \rangle = 4J$. The average over γ would be

$$\langle \gamma \rangle = (3 - 4\sin^2 \theta_W)J .$$

For $\sin^2 \theta_W = 3/4$ $\langle \gamma \rangle$ would vanish.

The quantum averages of classical weak fields quite generally vanish. What about correlation functions?

- (a) One expects that the correlators of classical weak fields as color invariants, and perhaps even symplectic invariants, are non-vanishing below the Compton length since in this kind of situation the points in the correlation function belong to the same 3-surface representing particle, such as hadron.
- (b) The intuitive picture is that in longer length scales one has disjoint 3-surfaces with a size scale of Compton length. If the states associated with two disjoint 3-surfaces are separately color invariant there are no correlations in color degrees of freedom and correlators reduce to the products of expectations of classical weak fields and vanish. This could also hold when the 3-surfaces are connected by flux tube bonds.

Below the Compton length weak bosons would thus behave as correlated massless fields. The Compton lengths of weak bosons are proportional to the value of effective Planck constant h_{eff} and in living systems the Compton lengths are proposed to be even of the order of cell size. This would explain the mysterious chiral selection in living systems requiring large parity violation.

- (c) What about the averages and correlators of color gauge fields? Classical color gauge fields are proportional to the products of Hamiltonians of color isometries induced Kähler form and the expectations of color Hamiltonians give vanishing average above Compton length and therefore vanishing average. Correlators are non-vanishing below the hadron scale. Gluons do not propagate in long scales for the same reason as weak bosons. This is implied by color confinement, which has also classical description in the sense that 3-surfaces have necessarily a finite size.

A large value of h_{eff} allows colored states even in biological scales below the Compton length since in this kind of situation the points in the correlation function belong to the same 3-surface representing particle, such as dark hadron.

Discrete symmetries

The treatment of discrete symmetries C, P, and T is based on the following requirements:

- (a) Symmetries must be realized as purely geometric transformations.
- (b) Transformation properties of the field variables should be essentially the same as in the conventional quantum field theories [B7] .

The action of the reflection P on spinors of is given by

$$\Psi \rightarrow P\Psi = \gamma^0 \otimes \gamma^0 \Psi . \quad (\text{A-2.53})$$

in the representation of the gamma matrices for which γ^0 is diagonal. It should be noticed that W and Z^0 bosons break parity symmetry as they should since their charge matrices do not commute with the matrix of P .

The guess that a complex conjugation in CP_2 is associated with T transformation of the physicist turns out to be correct. One can verify by a direct calculation that pure Dirac action is invariant under T realized according to

$$\begin{aligned} m^k &\rightarrow T(M^k) , \\ \xi^k &\rightarrow \bar{\xi}^k , \\ \Psi &\rightarrow \gamma^1 \gamma^3 \otimes 1 \Psi . \end{aligned} \quad (\text{A-2.54})$$

The operation bearing closest resemblance to the ordinary charge conjugation corresponds geometrically to complex conjugation in CP_2 :

$$\begin{aligned} \xi^k &\rightarrow \bar{\xi}^k , \\ \Psi &\rightarrow \Psi^\dagger \gamma^2 \gamma^0 \otimes 1 . \end{aligned} \quad (\text{A-2.55})$$

As one might have expected symmetries CP and T are exact symmetries of the pure Dirac action.

A-3 Induction procedure and many-sheeted space-time

Since the classical gauge fields are closely related in TGD framework, it is not possible to have space-time sheets carrying only single kind of gauge field. For instance, em fields are accompanied by Z^0 fields for extremals of Kähler action.

Classical em fields are always accompanied by Z^0 field and some components of color gauge field. For extremals having homologically non-trivial sphere as a CP_2 projection em and Z^0 fields are the only non-vanishing electroweak gauge fields. For homologically trivial sphere only W fields are non-vanishing. Color rotations does not affect the situation.

For vacuum extremals all electro-weak gauge fields are in general non-vanishing although the net gauge field has $U(1)$ holonomy by 2-dimensionality of the CP_2 projection. Color gauge field has $U(1)$ holonomy for all space-time surfaces and quantum classical correspondence suggest a weak form of color confinement meaning that physical states correspond to color neutral members of color multiplets.

A-3.1 Induction procedure for gauge fields and spinor connection

Induction procedure for gauge potentials and spinor structure is a standard procedure of bundle theory. If one has embedding of some manifold to the base space of a bundle, the bundle structure can be induced so that it has as a base space the imbedded manifold, whose points have as fiber the fiber of embedding space at their image points. In the recent case the embedding of space-time surface to embedding space defines the induction procedure. The induced gauge potentials and gauge fields are projections of the spinor connection of the embedding space to the space-time surface (see <http://tgdtheory.fi/appfigures/induct.jpg>).

Induction procedure makes sense also for the spinor fields of embedding space and one obtains geometrization of both electroweak gauge potentials and of spinors. The new element is induction of gamma matrices which gives their projections at space-time surface.

As a matter of fact, the induced gamma matrices cannot appear in the counterpart of massless Dirac equation. To achieve super-symmetry, Dirac action must be replaced with Kähler-Dirac action for which gamma matrices are contractions of the canonical momentum currents of Kähler action with embedding space gamma matrices. Induced gamma matrices in Dirac action would correspond to 4-volume as action.

Fig. 9. Induction of spinor connection and metric as projection to the space-time surface. <http://tgdtheory.fi/appfigures/induct.jpg>.

A-3.2 Induced gauge fields for space-times for which CP_2 projection is a geodesic sphere

If one requires that space-time surface is an extremal of Kähler action and has a 2-dimensional CP_2 projection, only vacuum extremals and space-time surfaces for which CP_2 projection is a geodesic sphere, are allowed. Homologically non-trivial geodesic sphere correspond to vanishing W fields and homologically non-trivial sphere to non-vanishing W fields but vanishing γ and Z^0 . This can be verified by explicit examples.

$r = \infty$ surface gives rise to a homologically non-trivial geodesic sphere for which e_0 and e_3 vanish imply the vanishing of W field. For space-time sheets for which CP_2 projection is $r = \infty$ homologically non-trivial geodesic sphere of CP_2 one has

$$\gamma = \left(\frac{3}{4} - \frac{\sin^2(\theta_W)}{2}\right)Z^0 \simeq \frac{5Z^0}{8} \quad .$$

The induced W fields vanish in this case and they vanish also for all geodesic sphere obtained by $SU(3)$ rotation.

$Im(\xi^1) = Im(\xi^2) = 0$ corresponds to homologically trivial geodesic sphere. A more general representative is obtained by using for the phase angles of standard complex CP_2 coordinates constant values. In this case e^1 and e^3 vanish so that the induced em , Z^0 , and Kähler fields vanish but induced W fields are non-vanishing. This holds also for surfaces obtained by color rotation. Hence one can say that for non-vacuum extremals with 2-D CP_2 projection color rotations and weak symmetries commute.

A-3.3 Many-sheeted space-time

TGD space-time is many-sheeted: in other words, there are in general several space-sheets which have projection to the same M^4 region. Second manner to say this is that CP_2 coordinates are many-valued functions of M^4 coordinates. The original physical interpretation of many-sheeted space-time was not correct: it was assumed that single sheet corresponds to GRT space-time and this obviously leads to difficulties since the induced gauge fields are expressible in terms of only four embedding space coordinates.

Fig. 10. Illustration of many-sheeted space-time of TGD. <http://tgdtheory.fi/appfigures/manysheeted.jpg>

Superposition of effects instead of superposition of fields

The first objection against TGD is that superposition is not possible for induced gauge fields and induced metric. The resolution of the problem is that it is effects which need to superpose, not the fields.

Test particle topologically condenses simultaneously to all space-time sheets having a projection to same region of M^4 (that is touches them). The superposition of effects of fields at various space-time sheets replaces the superposition of fields. This is crucial for the understanding also how GRT space-time relates to TGD space-time, which is also in the appendix of this book).

Wormhole contacts

Wormhole contacts are key element of many-sheeted space-time. One does not expect them to be stable unless there is non-trivial Kähler magnetic flux flowing through them so that the throats look like Kähler magnetic monopoles.

Fig. 11. Wormhole contact. <http://tgdtheory.fi/appfigures/wormholecontact.jpg>

Since the flow lines of Kähler magnetic field must be closed this requires the presence of another wormhole contact so that one obtains closed monopole flux tube decomposing to two Minkowskian pieces at the two space-time sheets involved and two wormhole contacts with Euclidian signature of the induced metric. These objects are identified as space-time correlates of elementary particles and are clearly analogous to string like objects.

The relationship between the many-sheeted space-time of TGD and of GRT space-time

The space-time of general relativity is single-sheeted and there is no need to regard it as surface in H although the assumption about representability as vacuum extremal gives very powerful constraints in cosmology and astrophysics and might make sense in simple situations.

The space-time of GRT can be regarded as a long length scale approximation obtained by lumping together the sheets of the many-sheeted space-time to a region of M^4 and providing it with an effective metric obtained as sum of M^4 metric and deviations of the induced metrics of various space-time sheets from M^4 metric. Also induced gauge potentials sum up in the similar manner so that also the gauge fields of gauge theories would not be fundamental fields.

Fig. 12. The superposition of fields is replaced with the superposition of their effects in many-sheeted space-time. <http://tgdtheory.fi/appfigures/fieldsuperpose.jpg>

Space-time surfaces of TGD are considerably simpler objects than the space-times of general relativity and relate to GRT space-time like elementary particles to systems of condensed matter physics. Same can be said about fields since all fields are expressible in terms of embedding space coordinates and their gradients, and general coordinate invariance means that the number of bosonic field degrees is reduced locally to 4. TGD space-time can be said to be a microscopic description whereas GRT space-time a macroscopic description. In TGD complexity of space-time topology replaces the complexity due to large number of fields in quantum field theory.

Topological field quantization and the notion of magnetic body

Topological field quantization also TGD from Maxwell's theory. TGD predicts topological light rays ("massless extremals (MEs)") as space-time sheets carrying waves or arbitrary shape propagating with maximal signal velocity in single direction only and analogous to laser beams and carrying light-like gauge currents in the general case. There are also magnetic flux quanta and electric flux quanta. The deformations of cosmic strings with 2-D string orbit

as M^4 projection gives rise to magnetic flux tubes carrying monopole flux made possible by CP_2 topology allowing homological Kähler magnetic monopoles.

Fig. 13. Topological quantization for magnetic fields replaces magnetic fields with bundles of them defining flux tubes as topological field quanta. <http://tgdtheory.fi/appfigures/field.jpg>

The imbeddability condition for say magnetic field means that the region containing constant magnetic field splits into flux quanta, say tubes and sheets carrying constant magnetic field. Unless one assumes a separate boundary term in Kähler action, boundaries in the usual sense are forbidden except as ends of space-time surfaces at the boundaries of causal diamonds. One obtains typically pairs of sheets glued together along their boundaries giving rise to flux tubes with closed cross section possibly carrying monopole flux.

These kind of flux tubes might make possible magnetic fields in cosmic scales already during primordial period of cosmology since no currents are needed to generate these magnetic fields: cosmic string would be indeed this kind of objects and would dominated during the primordial period. Even superconductors and maybe even ferromagnets could involve this kind of monopole flux tubes.

A-3.4 Embedding space spinors and induced spinors

One can geometrize also fermionic degrees of freedom by inducing the spinor structure of $M^4 \times CP_2$.

CP_2 does not allow spinor structure in the ordinary sense but one can couple the opposite H -chiralities of H -spinors to an $n = 1$ ($n = 3$) integer multiple of Kähler gauge potential to obtain a respectable modified spinor structure. The em charges of resulting spinors are fractional (integer valued) and the interpretation as quarks (leptons) makes sense since the couplings to the induced spinor connection having interpretation in terms electro-weak gauge potential are identical to those assumed in standard model.

The notion of quark color differs from that of standard model.

- (a) Spinors do not couple to color gauge potential although the identification of color gauge potential as projection of $SU(3)$ Killing vector fields is possible. This coupling must emerge only at the effective gauge theory limit of TGD.
- (b) Spinor harmonics of embedding space correspond to triality $t = 1$ ($t = 0$) partial waves. The detailed correspondence between color and electroweak quantum numbers is however not correct as such and the interpretation of spinor harmonics of embedding space is as representations for ground states of super-conformal representations. The wormhole pairs associated with physical quarks and leptons must carry also neutrino pair to neutralize weak quantum numbers above the length scale of flux tube (weak scale or Compton length). The total color quantum numbers of these states must be those of standard model. For instance, the color quantum numbers of fundamental left-hand neutrino and lepton can compensate each other for the physical lepton. For fundamental quark-lepton pair they could sum up to those of physical quark.

The well-definedness of em charge is crucial condition.

- (a) Although the embedding space spinor connection carries W gauge potentials one can say that the embedding space spinor modes have well-defined em charge. One expects that this is true for induced spinor fields inside wormhole contacts with 4-D CP_2 projection and Euclidian signature of the induced metric.
- (b) The situation is not the same for the modes of induced spinor fields inside Minkowskian region and one must require that the CP_2 projection of the regions carrying induced spinor field is such that the induced W fields and above weak scale also the induced Z^0 fields vanish in order to avoid large parity breaking effects. This condition forces the

CP_2 projection to be 2-dimensional. For a generic Minkowskian space-time region this is achieved only if the spinor modes are localized at 2-D surfaces of space-time surface - string world sheets and possibly also partonic 2-surfaces.

- (c) Also the Kähler-Dirac gamma matrices appearing in the modified Dirac equation must vanish in the directions normal to the 2-D surface in order that Kähler-Dirac equation can be satisfied. This does not seem plausible for space-time regions with 4-D CP_2 projection.
- (d) One can thus say that strings emerge from TGD in Minkowskian space-time regions. In particular, elementary particles are accompanied by a pair of fermionic strings at the opposite space-time sheets and connecting wormhole contacts. Quite generally, fundamental fermions would propagate at the boundaries of string world sheets as massless particles and wormhole contacts would define the stringy vertices of generalized Feynman diagrams. One obtains geometrized diagrammatics, which brings looks like a combination of stringy and Feynman diagrammatics.
- (e) This is what happens in the the generic situation. Cosmic strings could serve as examples about surfaces with 2-D CP_2 projection and carrying only em fields and allowing delocalization of spinor modes to the entire space-time surfaces.

A-3.5 About induced gauge fields

In the following the induced gauge fields are studied for general space-time surface without assuming the preferred extremal property (Bohr orbit property). Therefore the following arguments are somewhat obsolete in their generality.

Space-times with vanishing em, Z^0 , or Kähler fields

The following considerations apply to a more general situation in which the homologically trivial geodesic sphere and extremal property are not assumed. It must be emphasized that this case is possible in TGD framework only for a vanishing Kähler field.

Using spherical coordinates (r, Θ, Ψ, Φ) for CP_2 , the expression of Kähler form reads as

$$\begin{aligned} J &= \frac{r}{F^2} dr \wedge (d\Psi + \cos(\Theta)d\Phi) + \frac{r^2}{2F} \sin(\Theta) d\Theta \wedge d\Phi , \\ F &= 1 + r^2 . \end{aligned} \quad (\text{A-3.1})$$

The general expression of electromagnetic field reads as

$$\begin{aligned} F_{em} &= (3 + 2p) \frac{r}{F^2} dr \wedge (d\Psi + \cos(\Theta)d\Phi) + (3 + p) \frac{r^2}{2F} \sin(\Theta) d\Theta \wedge d\Phi , \\ p &= \sin^2(\Theta_W) , \end{aligned} \quad (\text{A-3.2})$$

where Θ_W denotes Weinberg angle.

- (a) The vanishing of the electromagnetic fields is guaranteed, when the conditions

$$\begin{aligned} \Psi &= k\Phi , \\ (3 + 2p) \frac{1}{r^2 F} (d(r^2)/d\Theta)(k + \cos(\Theta)) + (3 + p) \sin(\Theta) &= 0 , \end{aligned} \quad (\text{A-3.3})$$

hold true. The conditions imply that CP_2 projection of the electromagnetically neutral space-time is 2-dimensional. Solving the differential equation one obtains

$$\begin{aligned} r &= \sqrt{\frac{X}{1-X}} , \\ X &= D \left[\frac{k+u}{C} \right]^\epsilon , \\ u &\equiv \cos(\Theta) , \quad C = k + \cos(\Theta_0) , \quad D = \frac{r_0^2}{1+r_0^2} , \quad \epsilon = \frac{3+p}{3+2p} , \end{aligned} \quad (\text{A-3.4})$$

where C and D are integration constants. $0 \leq X \leq 1$ is required by the reality of r . $r = 0$ would correspond to $X = 0$ giving $u = -k$ achieved only for $|k| \leq 1$ and $r = \infty$ to $X = 1$ giving $|u+k| = [(1+r_0^2)/r_0^2]^{(3+2p)/(3+p)}$ achieved only for

$$\text{sign}(u+k) \times \left[\frac{1+r_0^2}{r_0^2} \right]^{\frac{3+2p}{3+p}} \leq k+1 ,$$

where $\text{sign}(x)$ denotes the sign of x .

The expressions for Kähler form and Z^0 field are given by

$$\begin{aligned} J &= -\frac{p}{3+2p} X du \wedge d\Phi , \\ Z^0 &= -\frac{6}{p} J . \end{aligned} \quad (\text{A-3.5})$$

The components of the electromagnetic field generated by varying vacuum parameters are proportional to the components of the Kähler field: in particular, the magnetic field is parallel to the Kähler magnetic field. The generation of a long range Z^0 vacuum field is a purely TGD based feature not encountered in the standard gauge theories.

- (b) The vanishing of Z^0 fields is achieved by the replacement of the parameter ϵ with $\epsilon = 1/2$ as becomes clear by considering the condition stating that Z^0 field vanishes identically. Also the relationship $F_{em} = 3J = -\frac{3}{4} \frac{r^2}{F} du \wedge d\Phi$ is useful.
- (c) The vanishing Kähler field corresponds to $\epsilon = 1, p = 0$ in the formula for em neutral space-times. In this case classical em and Z^0 fields are proportional to each other:

$$\begin{aligned} Z^0 &= 2e^0 \wedge e^3 = \frac{r}{F^2} (k+u) \frac{\partial r}{\partial u} du \wedge d\Phi = (k+u) du \wedge d\Phi , \\ r &= \sqrt{\frac{X}{1-X}} , \quad X = D|k+u| , \\ \gamma &= -\frac{p}{2} Z^0 . \end{aligned} \quad (\text{A-3.6})$$

For a vanishing value of Weinberg angle ($p = 0$) em field vanishes and only Z^0 field remains as a long range gauge field. Vacuum extremals for which long range Z^0 field vanishes but em field is non-vanishing are not possible.

The effective form of CP_2 metric for surfaces with 2-dimensional CP_2 projection

The effective form of the CP_2 metric for a space-time having vanishing em, Z^0 , or Kähler field is of practical value in the case of vacuum extremals and is given by

$$\begin{aligned} ds_{eff}^2 &= (s_{rr}(\frac{dr}{d\Theta})^2 + s_{\Theta\Theta})d\Theta^2 + (s_{\Phi\Phi} + 2ks_{\Phi\Psi})d\Phi^2 = \frac{R^2}{4}[s_{\Theta\Theta}^{eff}d\Theta^2 + s_{\Phi\Phi}^{eff}d\Phi^2] , \\ s_{\Theta\Theta}^{eff} &= X \times \left[\frac{\epsilon^2(1-u^2)}{(k+u)^2} \times \frac{1}{1-X} + 1 - X \right] , \\ s_{\Phi\Phi}^{eff} &= X \times [(1-X)(k+u)^2 + 1 - u^2] , \end{aligned} \quad (A-3.7)$$

and is useful in the construction of vacuum embedding of, say Schwarzschild metric.

Topological quantum numbers

Space-times for which either em, Z^0 , or Kähler field vanishes decompose into regions characterized by six vacuum parameters: two of these quantum numbers (ω_1 and ω_2) are frequency type parameters, two (k_1 and k_2) are wave vector like quantum numbers, two of the quantum numbers (n_1 and n_2) are integers. The parameters ω_i and n_i will be referred as electric and magnetic quantum numbers. The existence of these quantum numbers is not a feature of these solutions alone but represents a much more general phenomenon differentiating in a clear cut manner between TGD and Maxwell's electrodynamics.

The simplest manner to avoid surface Kähler charges and discontinuities or infinities in the derivatives of CP_2 coordinates on the common boundary of two neighboring regions with different vacuum quantum numbers is topological field quantization, 3-space decomposes into disjoint topological field quanta, 3-surfaces having outer boundaries with possibly macroscopic size.

Under rather general conditions the coordinates Ψ and Φ can be written in the form

$$\begin{aligned} \Psi &= \omega_2 m^0 + k_2 m^3 + n_2 \phi + \text{Fourier expansion} , \\ \Phi &= \omega_1 m^0 + k_1 m^3 + n_1 \phi + \text{Fourier expansion} . \end{aligned} \quad (A-3.8)$$

m^0, m^3 and ϕ denote the coordinate variables of the cylindrical M^4 coordinates) so that one has $k = \omega_2/\omega_1 = n_2/n_1 = k_2/k_1$. The regions of the space-time surface with given values of the vacuum parameters ω_i, k_i and n_i and m and C are bounded by the surfaces at which space-time surface becomes ill-defined, say by $r > 0$ or $r < \infty$ surfaces.

The space-time surface decomposes into regions characterized by different values of the vacuum parameters r_0 and Θ_0 . At $r = \infty$ surfaces n_2, ω_2 and m can change since all values of Ψ correspond to the same point of CP_2 : at $r = 0$ surfaces also n_1 and ω_1 can change since all values of Φ correspond to same point of CP_2 , too. If $r = 0$ or $r = \infty$ is not in the allowed range space-time surface develops a boundary.

This implies what might be called topological quantization since in general it is not possible to find a smooth global embedding for, say a constant magnetic field. Although global embedding exists it decomposes into regions with different values of the vacuum parameters and the coordinate u in general possesses discontinuous derivative at $r = 0$ and $r = \infty$ surfaces. A possible manner to avoid edges of space-time is to allow field quantization so that 3-space (and field) decomposes into disjoint quanta, which can be regarded as structurally stable units a 3-space (and of the gauge field). This doesn't exclude partial join along boundaries for neighboring field quanta provided some additional conditions guaranteeing the absence of edges are satisfied.

For instance, the vanishing of the electromagnetic fields implies that the condition

$$\Omega \equiv \frac{\omega_2}{n_2} - \frac{\omega_1}{n_1} = 0 \quad , \quad (\text{A-3.9})$$

is satisfied. In particular, the ratio ω_2/ω_1 is rational number for the electromagnetically neutral regions of space-time surface. The change of the parameter n_1 and n_2 (ω_1 and ω_2) in general generates magnetic field and therefore these integers will be referred to as magnetic (electric) quantum numbers.

A-4 The relationship of TGD to QFT and string models

The recent view of the relationship of TGD to QFT and string models has developed slowly during years and it seems that in a certain sense TGD means a return to roots: instead of QFT like description involving path integral one would have wave mechanics for 3-surfaces.

A-4.1 TGD as a generalization of wave mechanism obtained by replacing point-like particles with 3-surfaces

The first vision of TGD was as a generalization of quantum field theory (string models) obtained by replacing pointlike particles (strings) as fundamental objects with 3-surfaces.

The later work has revealed that TGD could be seen as a generalization of the wave mechanism based on the replacement of a point-like particle with 3-D surface. This is due to holography implied by general coordinate invariance. The definition of the metric of the "world of classical worlds" (WCW) must assign a unique or at least almost unique space-time surface to a given 3-surface. This 4-surface is analogous to Bohr orbit so that also Bohr orbitology becomes an exact part of quantum physics. The failure of strict determinism forces to replace 3-surfaces with 4-surfaces and this leads to zero energy ontology (ZEO) in which quantum states are superpositions of space-time surfaces [K60, K32, K102] [L116, L142].

Fig. 5. TGD replaces point-like particles with 3-surfaces. <http://tgdtheory.fi/appfigures/particletgd.jpg>

A-4.2 Extension of superconformal invariance

The fact that light-like 3-surfaces are effectively metrically 2-dimensional and thus possess generalization of 2-dimensional conformal symmetries with light-like radial coordinate defining the analog of second complex coordinate suggests that this generalization could work and extend the super-conformal symmetries to their 4-D analogs.

The boundary $\delta M_+^4 = S^2 \times R_{+-}$ of 4-D light-cone M_+^4 is also metrically 2-dimensional and allows extended conformal invariance. Also the group of isometries of light-cone boundary and of light-like 3-surfaces is infinite-dimensional since the conformal scalings of S^2 can be compensated by S^2 -local scaling of the light-like radial coordinate of R_+ . These simple facts mean that 4-dimensional Minkowski space and 4-dimensional space-time surfaces are in a completely unique position as far as symmetries are considered.

In fact, this leads to a generalization of the Kac-Moody type symmetries of string models. $\delta M_+^4 \times CP_2$ allows huge supersymplectic symmetries for which the radial light-like coordinate of δM_+^4 plays the role of complex string coordinate in string models. These symmetries are assumed to act as isometries of WCW.

A-4.3 String-like objects and strings

String like objects obtained as deformations of cosmic strings $X^2 \times Y^2$, where X^2 is minimal surface in M^4 and Y^2 a holomorphic surface of CP_2 are fundamental extremals of Kähler action having string world sheet as M^4 projections. Cosmic strings dominate the primordial cosmology of the TGD Universe and the inflationary period corresponds to the transition to radiation dominated cosmology for which space-time sheets with 4-D M^4 projection dominate.

Also genuine string-like objects emerge from TGD. The conditions that the em charge of modes of induced spinor fields is well-defined requires in the generic case the localization of the modes at 2-D surfaces -string world sheets and possibly also partonic 2-surfaces. This in Minkowskian space-time regions.

Fig. 6. Well-definedness of em charge forces the localization of induced spinor modes to 2-D surfaces in generic situations in Minkowskian regions of space-time surface. <http://tgdtheory.fi/appfigures/fermistring.jpg>

A-4.4 TGD view of elementary particles

The TGD based view about elementary particles has two key aspects.

- (a) The space-time correlates of elementary particles are identified as pairs of wormhole contacts with Euclidean signature of metric and having 4-D CP_2 projection. Their throats behave effectively as Kähler magnetic monopoles so that wormhole throats must be connected by Kähler magnetic flux tubes with monopole flux so that closed flux tubes are obtained.
- (b) At the level of H Fermion number is carried by the modes of the induced spinor field. In space-time regions with Minkowski signature the modes are localized at string world sheets connecting the wormhole contacts.

Fig. 7. TGD view about elementary particles. a) Particle orbit corresponds to a 4-D generalization of a world line or b) with its light-like 3-D boundary (holography). c) Particle world lines have Euclidean signature of the induced metric. d) They can be identified as wormhole contacts. e) The throats of wormhole contacts carry effective Kähler magnetic charges so that wormhole contacts must appear as pairs in order to obtain closed flux tubes. f) Wormhole contacts are accompanied by fermionic strings connecting the throats at the same sheet: the strings do not extend inside the wormhole contacts. <http://tgdtheory.fi/appfigures/elparticletgd.jpg>

Particle interactions involve both stringy and QFT aspects.

- (a) The boundaries of string world sheets correspond to fundamental fermions. This gives rise to massless propagator lines in generalized Feynman diagrammatics. One can speak of “long” string connecting wormhole contacts and having a hadronic string as a physical counterpart. Long strings should be distinguished from wormhole contacts which due to their super-conformal invariance behave like “short” strings with length scale given by CP_2 size, which is 10^4 times longer than Planck scale characterizing strings in string models.
- (b) Wormhole contact defines basic stringy interaction vertex for fermion-fermion scattering. The propagator is essentially the inverse of the superconformal scaling generator L_0 . Wormhole contacts containing fermion and antifermion at its opposite throats behave like virtual bosons so that one has BFF type vertices typically.
- (c) In topological sense one has 3-vertices serving as generalizations of 3-vertices of Feynman diagrams. In these vertices 4-D “lines” of generalized Feynman diagrams meet along their 3-D ends. One obtains also the analogs of stringy diagrams but stringy vertices do not have the usual interpretation in terms of particle decays but in terms of propagation of particles along two different routes.

Fig. 8. a) TGD analogs of Feynman and string diagrammatics at the level of space-time topology. b) The 4-D analogs of both string diagrams and QFT diagrams appear but the interpretation of the analogs stringy diagrams is different. <http://tgdtheory.fi/appfigures/tgdgraphs.jpg>

A-5 About the selection of the action defining the Kähler function of the "world of classical worlds" (WCW)

The proposal is that space-time surfaces correspond to preferred extremals of some action principle, being analogous to Bohr orbits, so that they are almost deterministic. The action for the preferred extremal would define the Kähler function of WCW [K60, K102].

How unique is the choice of the action defining WCW Kähler metric? The problem is that twistor lift strongly suggests the identification of the preferred extremals as 4-D surfaces having 4-D generalization of complex structure and that a large number of general coordinate invariant actions constructible in terms of the induced geometry have the same preferred extremals.

A-5.1 Could twistor lift fix the choice of the action uniquely?

The twistor lift of TGD [L57] [L116, L122, L123] generalizes the notion of induction to the level of twistor fields and leads to a proposal that the action is obtained by dimensional reduction of the action having as its preferred extremals the counterpart of twistor space of the space-time surface identified as 6-D surface in the product $T(M^4) \times T(CP_2)$ twistor spaces of $T(M^4)$ and $T(CP_2)$ of M^4 and CP_2 . Only M^4 and CP_2 allow a twistor space with Kähler structure [A19] so that TGD would be unique. Dimensional reduction is forced by the condition that the 6-surface has S^2 -bundle structure characterizing twistor spaces and the base space would be the space-time surface.

- (a) Dimensional reduction of 6-D Kähler action implies that at the space-time level the fundamental action can be identified as the sum of Kähler action and volume term (cosmological constant). Other choices of the action do not look natural in this picture although they would have the same preferred extremals.
- (b) Preferred extremals are proposed to correspond to minimal surfaces with singularities such that they are also extremals of 4-D Kähler action outside the singularities. The physical analogue are soap films spanned by frames and one can localize the violation of the strict determinism and of strict holography to the frames.
- (c) The preferred extremal property is realized as the holomorphicity characterizing string world sheets, which generalizes to the 4-D situation. This in turn implies that the preferred extremals are the same for any general coordinate invariant action defined on the induced gauge fields and induced metric apart from possible extremals with vanishing CP_2 Kähler action.

For instance, 4-D Kähler action and Weyl action as the sum of the tensor squares of the components of the Weyl tensor of CP_2 representing quaternionic imaginary units constructed from the Weyl tensor of CP_2 as an analog of gauge field would have the same preferred extremals and only the definition of Kähler function and therefore Kähler metric of WCW would change. One can even consider the possibility that the volume term in the 4-D action could be assigned to the tensor square of the induced metric representing a quaternionic or octonionic real unit.

Action principle does not seem to be unique. On the other hand, the WCW Kähler form and metric should be unique since its existence requires maximal isometries.

Unique action is not the only way to achieve this. One cannot exclude the possibility that the Kähler gauge potential of WCW in the complex coordinates of WCW differs only by

a complex gradient of a holomorphic function for different actions so that they would give the same Kähler form for WCW. This gradient is induced by a symplectic transformation of WCW inducing a $U(1)$ gauge transformation. The Kähler metric is the same if the symplectic transformation is an isometry.

Symplectic transformations of WCW could give rise to inequivalent representations of the theory in terms of action at space-time level. Maybe the length scale dependent coupling parameters of an effective action could be interpreted in terms of a choice of WCW Kähler function, which maximally simplifies the computations at a given scale.

- (a) The 6-D analogues of electroweak action and color action reducing to Kähler action in 4-D case exist. The 6-D analog of Weyl action based on the tensor representation of quaternionic imaginary units does not however exist. One could however consider the possibility that only the base space of twistor space $T(M^4)$ and $T(CP_2)$ have quaternionic structure.
- (b) Kähler action has a huge vacuum degeneracy, which clearly distinguishes it from other actions. The presence of the volume term removes this degeneracy. However, for minimal surfaces having CP_2 projections, which are Lagrangian manifolds and therefore have a vanishing induced Kähler form, would be preferred extremals according to the proposed definition. For these 4-surfaces, the existence of the generalized complex structure is dubious.

For the electroweak action, the terms corresponding to charged weak bosons eliminate these extremals and one could argue that electroweak action or its sum with the analogue of color action, also proportional Kähler action, defines the more plausible choice. Interestingly, also the neutral part of electroweak action is proportional to Kähler action.

Twistor lift strongly suggests that also M^4 has the analog of Kähler structure. M^8 must be complexified by adding a commuting imaginary unit i . In the E^8 subspace, the Kähler structure of E^4 is defined in the standard sense and it is proposed that this generalizes to M^4 allowing also generalization of the quaternionic structure. M^4 Kähler structure violates Lorentz invariance but could be realized at the level of moduli space of these structures.

The minimal possibility is that the M^4 Kähler form vanishes: one can have a different representation of the Kähler gauge potential for it obtained as generalization of symplectic transformations acting non-trivially in M^4 . The recent picture about the second quantization of spinors of $M^4 \times CP_2$ assumes however non-trivial Kähler structure in M^4 .

A-5.2 Two paradoxes

TGD view leads to two apparent paradoxes.

- (a) If the preferred extremals satisfy 4-D generalization of holomorphicity, a very large set of actions gives rise to the same preferred extremals unless there are some additional conditions restricting the number of preferred extremals for a given action.
- (b) WCW metric has an infinite number of zero modes, which appear as parameters of the metric but do not contribute to the line element. The induced Kähler form depends on these degrees of freedom. The existence of the Kähler metric requires maximal isometries, which suggests that the Kähler metric is uniquely fixed apart from a conformal scaling factor Ω depending on zero modes. This cannot be true: galaxy and elementary particle cannot correspond to the same Kähler metric.

Number theoretical vision and the hierarchy of inclusions of HFFs associated with supersymplectic algebra acting as isometries of WcW provide equivalent realizations of the measurement resolution. This solves these paradoxes and predicts that WCW decomposes into sectors for which Kähler metrics of WCW differ in a natural way.

The hierarchy subalgebras of supersymplectic algebra implies the decomposition of WCW into sectors with different actions

Supersymplectic algebra of $\delta M_+^4 \times CP_2$ is assumed to act as isometries of WCW [L142]. There are also other important algebras but these will not be discussed now.

- (a) The symplectic algebra A of $\delta M_+^4 \times CP_2$ has the structure of a conformal algebra in the sense that the radial conformal weights with non-negative real part, which is half integer, label the elements of the algebra have an interpretation as conformal weights.

The super symplectic algebra A has an infinite hierarchy of sub-algebras [L142] such that the conformal weights of sub-algebras $A_{n(SS)}$ are integer multiples of the conformal weights of the entire algebra. The superconformal gauge conditions are weakened. Only the subalgebra $A_{n(SS)}$ and the commutator $[A_{n(SS)}, A]$ annihilate the physical states. Also the corresponding classical Noether charges vanish for allowed space-time surfaces.

This weakening makes sense also for ordinary superconformal algebras and associated Kac-Moody algebras. This hierarchy can be interpreted as a hierarchy symmetry breakings, meaning that sub-algebra $A_{n(SS)}$ acts as genuine dynamical symmetries rather than mere gauge symmetries. It is natural to assume that the super-symplectic algebra A does not affect the coupling parameters of the action.

- (b) The generators of A correspond to the dynamical quantum degrees of freedom and leave the induced Kähler form invariant. They affect the induced space-time metric but this effect is gravitational and very small for Einsteinian space-time surfaces with 4-D M^4 projection.

The number of dynamical degrees of freedom increases with $n(SS)$. Therefore WCW decomposes into sectors labelled by $n(SS)$ with different numbers of dynamical degrees of freedom so that their Kähler metrics cannot be equivalent and cannot be related by a symplectic isometry. They can correspond to different actions.

Number theoretic vision implies the decomposition of WCW into sectors with different actions

The number theoretical vision leads to the same conclusion as the hierarchy of HFFs. The number theoretic vision of TGD based on $M^8 - H$ duality [L142] predicts a hierarchy with levels labelled by the degrees $n(P)$ of rational polynomials P and corresponding extensions of rationals characterized by Galois groups and by ramified primes defining p-adic length scales.

These sequences allow us to imagine several discrete coupling constant evolutions realized at the level H in terms of action whose coupling parameters depend on the number theoretic parameters.

1. Coupling constant evolution with respect to $n(P)$

The first coupling constant evolution would be with respect to $n(P)$.

- (a) The coupling constants characterizing action could depend on the degree $n(P)$ of the polynomial defining the space-time region by $M^8 - H$ duality. The complexity of the space-time surface would increase with $n(P)$ and new degrees of freedom would emerge as the number of the rational coefficients of P .
- (b) This coupling constant evolution could naturally correspond to that assignable to the inclusion hierarchy of hyperfinite factors of type II_1 (HFFs). I have indeed proposed [L142] that the degree $n(P)$ equals to the number $n(braid)$ of braids assignable to HFF for which super symplectic algebra subalgebra $A_{n(SS)}$ with radial conformal weights coming as $n(SS)$ -multiples of those of entire algebra A . One would have $n(P) = n(braid) = n(SS)$. The number of dynamical degrees of freedom increases with n which just as it increases with $n(P)$ and $n(SS)$.

- (c) The actions related to different values of $n(P) = n(\text{braid}) = n(SS)$ cannot define the same Kähler metric since the number of allowed space-time surfaces depends on $n(SS)$.

WCW could decompose to sub-WCWs corresponding to different actions, a kind of theory space. These theories would not be equivalent. A possible interpretation would be as a hierarchy of effective field theories.

- (d) Hierarchies of composite polynomials define sequences of polynomials with increasing values of $n(P)$ such that the order of a polynomial at a given level is divided by those at the lower levels. The proposal is that the inclusion sequences of extensions are realized at quantum level as inclusion hierarchies of hyperfinite factors of type II_1 .

A given inclusion hierarchy corresponds to a sequence $n(SS)_i$ such that $n(SS)_i$ divides $n(SS)_{i+1}$. Therefore the degree of the composite polynomials increases very rapidly. The values of $n(SS)_i$ can be chosen to be primes and these primes correspond to the degrees of so called prime polynomials [L126] so that the decompositions correspond to prime factorizations of integers. The "densest" sequence of this kind would come in powers of 2 as $n(SS)_i = 2^i$. The corresponding p-adic length scales (assignable to maximal ramified primes for given $n(SS)_i$) are expected to increase roughly exponentially, say as 2^{r2^i} . $r = 1/2$ would give a subset of scales $2^{r/2}$ allowed by the p-adic length scale hypothesis. These transitions would be very rare.

A theory corresponding to a given composite polynomial would contain as sub-theories the theories corresponding to lower polynomial composites. The evolution with respect to $n(SS)$ would correspond to a sequence of phase transitions in which the action genuinely changes. For instance, color confinement could be seen as an example of this phase transition.

- (e) A subset of p-adic primes allowed by the p-adic length scale hypothesis $p \simeq 2^k$ defining the proposed p-adic length scale hierarchy could relate to n_S changing phase transition. TGD suggests a hierarchy of hadron physics corresponding to a scale hierarchy defined by Mersenne primes and their Gaussian counterparts [K74, K75]). Each of them would be characterized by a confinement phase transition in which n_S and therefore also the action changes.

2. Coupling constant evolutions with respect to ramified primes for a given value of $n(P)$

For a given value of $n(P)$, one could have coupling constant sub-evolutions with respect to the set of ramified primes of P and dimensions $n = h_{eff}/h_0$ of algebraic extensions. The action would only change by $U(1)$ gauge transformation induced by a symplectic isometry of WCW. Coupling parameters could change but the actions would be equivalent.

The choice of the action in an optimal manner in a given scale could be seen as a choice of the most appropriate effective field theory in which radiative corrections would be taken into account. One can interpret the possibility to use a single choice of coupling parameters in terms of quantum criticality.

The range of the p-adic length scales labelled by ramified primes and effective Planck constants h_{eff}/h_0 is finite for a given value of $n(SS)$.

The first coupling constant evolution of this kind corresponds to ramified primes defining p-adic length scales for given $n(SS)$.

- (a) Ramified primes are factors of the discriminant $D(P)$ of P , which is expressible as a product of non-vanishing root differentials and reduces to a polynomial of the n coefficients of P . Ramified primes define p-adic length scales assignable to the particles in the amplitudes scattering amplitudes defined by zero energy states.

P would represent the space-time surface defining an interaction region in N -particle scattering. The N ramified primes dividing $D(P)$ would characterize the p-adic length scales assignable to these particles. If $D(P)$ reduces to a single ramified prime, one has

elementary particle [L126], and the forward scattering amplitude corresponds to the propagator.

This would give rise to a multi-scale p-adic length scale evolution of the amplitudes analogous to the ordinary continuous coupling constant evolution of n-point scattering amplitudes with respect to momentum scales of the particles. This kind of evolutions extend also to evolutions with respect to $n(SS)$.

- (b) According to [L126], physical constraints require that $n(P)$ and the maximum size of the ramified prime of P correlate.

A given rational polynomial of degree $n(P)$ can be always transformed to a polynomial with integer coefficients. If the integer coefficients are smaller than $n(P)$, there is an upper bound for the ramified primes. This assumption also implies that finite fields become fundamental number fields in number theoretical vision [L126].

- (c) p-Adic length scale hypothesis [L143] in its basic form states that there exist preferred primes $p \simeq 2^k$ near some powers of 2. A more general hypothesis states that also primes near some powers of 3 possibly also other small primes are preferred physically. The challenge is to understand the origin of these preferred scales.

For polynomials P with a given degree $n(P)$ for which discriminant $D(P)$ is prime, there exists a maximal ramified prime. Numerical calculations suggest that the upper bound depends exponentially on $n(P)$.

Could these maximal ramified primes satisfy the p-adic length scale hypothesis or its generalization? The maximal prime defines a fixed point of coupling constant evolution in accordance with the earlier proposal. For instance, could one think that one has $p \simeq 2^k$, $k = n(SS)$? Each p-adic prime would correspond to a p-adic coupling constant sub-evolution representable in terms of symplectic isometries.

Also the dimension n of the algebraic extension associated with P , which is identified in terms of effective Planck constant $h_{eff}/h_0 = n$ labelling different phases of the ordinary matter behaving like dark matter, could give rise to coupling constant evolution for given $n(SS)$. The range of allowed values of n is finite. Note however that several polynomials of a given degree can correspond to the same dimension of extension.

Number theoretic discretization of WCW and maxima of WCW Kähler function

Number theoretic approach involves a unique discretization of space-time surface and also of WCW. The question is how the points of the discretized WCW correspond to the preferred extremals.

- (a) The exponents of Kähler function for the maxima of Kähler function, which correspond to the universal preferred extremals, appear in the scattering amplitudes. The number theoretical approach involves a unique discretization of space-time surfaces defining the WCW coordinates of the space-time surface regarded as a point of WCW.

In [L142] it is assumed that these WCW points appearing in the number theoretical discretization correspond to the maxima of the Kähler function. The maxima would depend on the action and would differ for ghd maxima associated with different actions unless they are not related by symplectic WCW isometry.

- (b) The symplectic transformations of WCW acting as isometries are assumed to be induced by the symplectic transformations of $\delta M_+^4 \times CP_2$ [K60, K32]. As isometries they would naturally permute the maxima with each other.

A-6 Number theoretic vision of TGD

Physics as number theory vision is complementary to the physics as geometry vision and has developed gradually since 1993. Langlands program is the counterpart of this vision in mathematics [L136].

The notion of p-adic number fields emerged with the motivation coming from the observation that elementary particle mass scales and mass ratios could be understood in terms of the so-called p-adic length scale hypothesis [K78, K69, K29]. The fusion of the various p-adic physics leads to what I call adelic physics [L55, L56]. Later the hypothesis about hierarchy of Planck constants labelling phases of ordinary matter behaving like dark matter emerged [K36, K37, K38, K39].

Eventually this led to that the values of effective Planck constant could be identified as the dimension of an algebraic extension of rationals assignable to polynomials with rational coefficients. This led to the number theoretic vision in which so-called $M^8 - H$ duality [L90, L91] plays a key role. M^8 (actually a complexification of real M^8) is analogous to momentum space so that the duality generalizes momentum position duality for point-like particles. M^8 has an interpretation as complexified octonions.

The dynamics of 4-surfaces in M^8 is coded by polynomials with rational coefficients, whose roots define mass shells H^3 of $M^4 \subset M^8$. It has turned out that the polynomials satisfy stringent additional conditions and one can speak of number theoretic holography [L126, L136]. Also the ordinary $3 \rightarrow 4$ holography is needed to assign 4-surfaces with these 3-D mass shells. The number theoretic dynamics is based on the condition that the normal space of the 4-surface in M^8 is associative (quaternionic) and contains a commutative complex sub-space. This makes it possible to assign to this surface space-time surface in $H = M^4 \times CP_2$.

At the level of H the space-time surfaces are by holography preferred extremals and are assumed to be determined by the twistor lift of TGD [L57] giving rise to an action which is sum of the Kähler action and volume term. The preferred extremals would be minimal surfaces analogous to soap films spanned by frames. Outside frames they would be simultaneous extremals of the Kähler action, which requires a generalization of the holomorphy characterizing string world sheets.

In the following only p-adic numbers and hierarchy of Planck constants will be discussed.

A-6.1 p-Adic numbers and TGD

p-Adic number fields

p-Adic numbers (p is prime: 2, 3, 5, ...) can be regarded as a completion of the rational numbers using a norm, which is different from the ordinary norm of real numbers [A10]. p-Adic numbers are representable as power expansion of the prime number p of form

$$x = \sum_{k \geq k_0} x(k)p^k, \quad x(k) = 0, \dots, p-1. \quad (\text{A-6.1})$$

The norm of a p-adic number is given by

$$|x| = p^{-k_0(x)}. \quad (\text{A-6.2})$$

Here $k_0(x)$ is the lowest power in the expansion of the p-adic number. The norm differs drastically from the norm of the ordinary real numbers since it depends on the lowest pinary digit of the p-adic number only. Arbitrarily high powers in the expansion are possible since

the norm of the p-adic number is finite also for numbers, which are infinite with respect to the ordinary norm. A convenient representation for p-adic numbers is in the form

$$x = p^{k_0} \varepsilon(x) , \quad (\text{A-6.3})$$

where $\varepsilon(x) = k + \dots$ with $0 < k < p$, is p-adic number with unit norm and analogous to the phase factor $\exp(i\phi)$ of a complex number.

The distance function $d(x, y) = |x - y|_p$ defined by the p-adic norm possesses a very general property called ultra-metricity:

$$d(x, z) \leq \max\{d(x, y), d(y, z)\} . \quad (\text{A-6.4})$$

The properties of the distance function make it possible to decompose R_p into a union of disjoint sets using the criterion that x and y belong to same class if the distance between x and y satisfies the condition

$$d(x, y) \leq D . \quad (\text{A-6.5})$$

This division of the metric space into classes has following properties:

- (a) Distances between the members of two different classes X and Y do not depend on the choice of points x and y inside classes. One can therefore speak about distance function between classes.
- (b) Distances of points x and y inside single class are smaller than distances between different classes.
- (c) Classes form a hierarchical tree.

Notice that the concept of the ultra-metricity emerged in physics from the models for spin glasses and is believed to have also applications in biology [B14]. The emergence of p-adic topology as the topology of the effective space-time would make ultra-metricity property basic feature of physics.

Canonical correspondence between p-adic and real numbers

The basic challenge encountered by p-adic physicist is how to map the predictions of the p-adic physics to real numbers. p-Adic probabilities provide a basic example in this respect. Identification via common rationals and canonical identification and its variants have turned out to play a key role in this respect.

1. Basic form of the canonical identification

There exists a natural continuous map $I : R_p \rightarrow R_+$ from p-adic numbers to non-negative real numbers given by the “pinary” expansion of the real number for $x \in R$ and $y \in R_p$ this correspondence reads

$$\begin{aligned} y &= \sum_{k > N} y_k p^k \rightarrow x = \sum_{k < N} y_k p^{-k} , \\ y_k &\in \{0, 1, \dots, p-1\} . \end{aligned} \quad (\text{A-6.6})$$

This map is continuous as one easily finds out. There is however a little difficulty associated with the definition of the inverse map since the pinary expansion like also decimal expansion is not unique ($1 = 0.999\dots$) for the real numbers x , which allow pinary expansion with finite number of pinary digits

$$\begin{aligned} x &= \sum_{k=N_0}^N x_k p^{-k} , \\ x &= \sum_{k=N_0}^{N-1} x_k p^{-k} + (x_N - 1)p^{-N} + (p-1)p^{-N-1} \sum_{k=0,\dots} p^{-k} . \end{aligned} \quad (\text{A-6.7})$$

The p-adic images associated with these expansions are different

$$\begin{aligned} y_1 &= \sum_{k=N_0}^N x_k p^k , \\ y_2 &= \sum_{k=N_0}^{N-1} x_k p^k + (x_N - 1)p^N + (p-1)p^{N+1} \sum_{k=0,\dots} p^k \\ &= y_1 + (x_N - 1)p^N - p^{N+1} , \end{aligned} \quad (\text{A-6.8})$$

so that the inverse map is either two-valued for p-adic numbers having expansion with finite pinary digits or single valued and discontinuous and non-surjective if one makes pinary expansion unique by choosing the one with finite pinary digits. The finite pinary digit expansion is a natural choice since in the numerical work one always must use a pinary cutoff on the real axis.

2. The topology induced by canonical identification

The topology induced by the canonical identification in the set of positive real numbers differs from the ordinary topology. The difference is easily understood by interpreting the p-adic norm as a norm in the set of the real numbers. The norm is constant in each interval $[p^k, p^{k+1})$ (see **Fig. A-6.1**) and is equal to the usual real norm at the points $x = p^k$: the usual linear norm is replaced with a piecewise constant norm. This means that p-adic topology is coarser than the usual real topology and the higher the value of p is, the coarser the resulting topology is above a given length scale. This hierarchical ordering of the p-adic topologies will be a central feature as far as the proposed applications of the p-adic numbers are considered.

Ordinary continuity implies p-adic continuity since the norm induced from the p-adic topology is rougher than the ordinary norm. p-Adic continuity implies ordinary continuity from right as is clear already from the properties of the p-adic norm (the graph of the norm is indeed continuous from right). This feature is one clear signature of the p-adic topology.

Fig. 14. The real norm induced by canonical identification from 2-adic norm. <http://tgdtheory.fi/appfigures/norm.png>

The linear structure of the p-adic numbers induces a corresponding structure in the set of the non-negative real numbers and p-adic linearity in general differs from the ordinary concept of linearity. For example, p-adic sum is equal to real sum only provided the summands have no common pinary digits. Furthermore, the condition $x +_p y < \max\{x, y\}$ holds in general for the p-adic sum of the real numbers. p-Adic multiplication is equivalent with the ordinary multiplication only provided that either of the members of the product is power of p .

Moreover one has $x \times_p y < x \times y$ in general. The p-Adic negative -1_p associated with p-adic unit 1 is given by $(-1)_p = \sum_k (p-1)p^k$ and defines p-adic negative for each real number x . An interesting possibility is that p-adic linearity might replace the ordinary linearity in some strongly nonlinear systems so these systems would look simple in the p-adic topology.

These results suggest that canonical identification is involved with some deeper mathematical structure. The following inequalities hold true:

$$\begin{aligned} (x+y)_R &\leq x_R + y_R , \\ |x|_p |y|_R \leq (xy)_R &\leq x_R y_R , \end{aligned} \quad (\text{A-6.9})$$

where $|x|_p$ denotes p-adic norm. These inequalities can be generalized to the case of $(R_p)^n$ (a linear vector space over the p-adic numbers).

$$\begin{aligned} (x+y)_R &\leq x_R + y_R , \\ |\lambda|_p |y|_R \leq (\lambda y)_R &\leq \lambda_R y_R , \end{aligned} \quad (\text{A-6.10})$$

where the norm of the vector $x \in T_p^n$ is defined in some manner. The case of Euclidian space suggests the definition

$$(x_R)^2 = \left(\sum_n x_n^2 \right)_R . \quad (\text{A-6.11})$$

These inequalities resemble those satisfied by the vector norm. The only difference is the failure of linearity in the sense that the norm of a scaled vector is not obtained by scaling the norm of the original vector. Ordinary situation prevails only if the scaling corresponds to a power of p .

These observations suggests that the concept of a normed space or Banach space might have a generalization and physically the generalization might apply to the description of some non-linear systems. The nonlinearity would be concentrated in the nonlinear behavior of the norm under scaling.

3. Modified form of the canonical identification

The original form of the canonical identification is continuous but does not respect symmetries even approximately. This led to a search of variants which would do better in this respect. The modification of the canonical identification applying to rationals only and given by

$$I_Q(q = p^k \times \frac{r}{s}) = p^k \times \frac{I(r)}{I(s)} \quad (\text{A-6.12})$$

is uniquely defined for rationals, maps rationals to rationals, has also a symmetry under exchange of target and domain. This map reduces to a direct identification of rationals for $0 \leq r < p$ and $0 \leq s < p$. It has turned out that it is this map which most naturally appears in the applications. The map is obviously continuous locally since p-adically small modifications of r and s mean small modifications of the real counterparts.

Canonical identification is in a key role in the successful predictions of the elementary particle masses. The predictions for the light elementary particle masses are within extreme accuracy same for I and I_Q but I_Q is theoretically preferred since the real probabilities obtained from p-adic ones by I_Q sum up to one in p-adic thermodynamics.

4. Generalization of number concept and notion of embedding space

TGD forces an extension of number concept: roughly a fusion of reals and various p-adic number fields along common rationals is in question. This induces a similar fusion of real and p-adic embedding spaces. Since finite p-adic numbers correspond always to non-negative reals n -dimensional space R^n must be covered by 2^n copies of the p-adic variant R_p^n of R^n each of which projects to a copy of R_+^n (four quadrants in the case of plane). The common points of p-adic and real embedding spaces are rational points and most p-adic points are at real infinity.

Real numbers and various algebraic extensions of p-adic number fields are thus glued together along common rationals and also numbers in algebraic extension of rationals whose number belong to the algebraic extension of p-adic numbers. This gives rise to a book like structure with rationals and various algebraic extensions of rationals taking the role of the back of the book. Note that Neper number is exceptional in the sense that it is algebraic number in p-adic number field Q_p satisfying $e^p \bmod p = 1$.

Fig. 15. Various number fields combine to form a book like structure. <http://tgdtheory.fi/appfigures/book.jpg>

For a given p-adic space-time sheet most points are literally infinite as real points and the projection to the real embedding space consists of a discrete set of rational points: the interpretation in terms of the unavoidable discreteness of the physical representations of cognition is natural. Purely local p-adic physics implies real p-adic fractality and thus long range correlations for the real space-time surfaces having enough common points with this projection.

p-Adic fractality means that M^4 projections for the rational points of space-time surface X^4 are related by a direct identification whereas CP_2 coordinates of X^4 at these points are related by I, I_Q or some of its variants implying long range correlates for CP_2 coordinates. Since only a discrete set of points are related in this manner, both real and p-adic field equations can be satisfied and there are no problems with symmetries. p-Adic effective topology is expected to be a good approximation only within some length scale range which means infrared and UV cutoffs. Also multi-p-fractality is possible.

The notion of p-adic manifold

The notion of p-adic manifold is needed in order to fuse real physics and various p-adic physics to a larger structure which suggests that real and p-adic number fields should be glued together along common rationals bringing in mind adeles. The notion is problematic because p-adic topology is totally disconnected implying that p-adic balls are either disjoint or nested so that ordinary definition of manifold using p-adic chart maps fails. A cure is suggested to be based on chart maps from p-adics to reals rather than to p-adics (see the appendix of the book)

The chart maps are interpreted as cognitive maps, “thought bubbles”.

Fig. 16. The basic idea between p-adic manifold. <http://tgdtheory.fi/appfigures/padmanifold.jpg>

There are some problems.

- (a) Canonical identification does not respect symmetries since it does not commute with second pinary cutoff so that only a discrete set of rational points is mapped to their real counterparts by chart map arithmetic operations which requires pinary cutoff below which chart map takes rationals to rationals so that commutativity with arithmetics and symmetries is achieved in finite resolution: above the cutoff canonical identification is used
- (b) Canonical identification is continuous but does not map smooth p-adic surfaces to smooth real surfaces requiring second pinary cutoff so that only a discrete set of rational points is mapped to their real counterparts by chart map requiring completion of the

image to smooth preferred extremal of Kähler action so that chart map is not unique in accordance with finite measurement resolution

- (c) Canonical identification violates general coordinate invariance of chart map: (cognition-induced symmetry breaking) minimized if p-adic manifold structure is induced from that for p-adic embedding space with chart maps to real embedding space and assuming preferred coordinates made possible by isometries of embedding space: one however obtains several inequivalent p-adic manifold structures depending on the choice of coordinates: these cognitive representations are not equivalent.

A-6.2 Hierarchy of Planck constants and dark matter hierarchy

Hierarchy of Planck constants was motivated by the “impossible” quantal effects of ELF em fields on vertebrate cyclotron energies $E = hf = \hbar \times eB/m$ are above thermal energy is possible only if \hbar has value much larger than its standard value. Also Nottale’s finding that planetary orbits might be understood as Bohr orbits for a gigantic gravitational Planck constant.

Hierarchy of Planck constant would mean that the values of Planck constant come as integer multiples of ordinary Planck constant: $h_{eff} = n \times h$. The particles at magnetic flux tubes characterized by h_{eff} would correspond to dark matter which would be invisible in the sense that only particle with same value of h_{eff} appear in the same vertex of Feynman diagram.

Hierarchy of Planck constants would be due to the non-determinism of the Kähler action predicting huge vacuum degeneracy allowing all space-time surfaces which are sub-manifolds of any $M^4 \times Y^2$, where Y^2 is Lagrangian sub-manifold of CP_2 . For a given Y^2 one obtains new manifolds Y^2 by applying symplectic transformations of CP_2 .

Non-determinism would mean that the 3-surface at the ends of causal diamond (CD) can be connected by several space-time surfaces carrying same conserved Kähler charges and having same values of Kähler action. Conformal symmetries defined by Kac-Moody algebra associated with the embedding space isometries could act as gauge transformations and respect the light-likeness property of partonic orbits at which the signature of the induced metric changes from Minkowskian to Euclidian (Minkowskian space-time region transforms to wormhole contact say). The number of conformal equivalence classes of these surfaces could be finite number n and define discrete physical degree of freedom and one would have $h_{eff} = n \times h$. This degeneracy would mean “second quantization” for the sheets of n-furcation: not only one but several sheets can be realized.

This relates also to quantum criticality postulated to be the basic characteristics of the dynamics of quantum TGD. Quantum criticalities would correspond to an infinite fractal hierarchy of broken conformal symmetries defined by sub-algebras of conformal algebra with conformal weights coming as integer multiples of n . This leads also to connections with quantum criticality and hierarchy of broken conformal symmetries, p-adicity, and negentropic entanglement which by consistency with standard quantum measurement theory would be described in terms of density matrix proportional $n \times n$ identity matrix and being due to unitary entanglement coefficients (typical for quantum computing systems).

Formally the situation could be described by regarding space-time surfaces as surfaces in singular n-fold singular coverings of embedding space. A stronger assumption would be that they are expressible as products of n_1 -fold covering of M^4 and n_2 -fold covering of CP_2 meaning analogy with multi-sheeted Riemann surfaces and that M^4 coordinates are n_1 -valued functions and CP_2 coordinates n_2 -valued functions of space-time coordinates for $n = n_1 \times n_2$. These singular coverings of embedding space form a book like structure with singularities of the coverings localizable at the boundaries of causal diamonds defining the back of the book like structure.

Fig. 17. Hierarchy of Planck constants. <http://tgdtheory.fi/appfigures/planckhierarchy.jpg>

A-6.3 $M^8 - H$ duality as it is towards the end of 2021

The view of $M^8 - H$ duality (see Appendix ??) has changed considerably towards the end 2021 [L116] after the realization that this duality is the TGD counterpart of momentum position duality of wave mechanics, which is lost in QFTs. Therefore M^8 and also space-time surface is analogous to momentum space. This forced us to give up the original simple identification of the points $M^4 \subset M^4 \times E^4 = M^8$ and of $M^4 \times CP_2$ so that it respects Uncertainty Principle (UP).

The first improved guess for the duality map was the replacement with the inversion $p^k \rightarrow m^k = \hbar_{eff} p^k / p^2$ conforming in spirit with UP but turned out to be too naive.

The improved form [L116] of the $M^8 - H$ duality map takes mass shells $p^2 = m^2$ of $M^4 \subset M^8$ to cds with size $L(m) = \hbar_{eff}/m$ with a common center. The slicing by mass shells is mapped to a Russian doll like slicing by cds. Therefore would be no CDs in M^8 contrary to what I believed first.

Quantum classical correspondence (QCC) inspires the proposal that the point $p^k \in M^8$ is mapped to a geodesic line corresponding to momentum p^k starting from the common center of cds. Its intersection with the opposite boundary of cd with size $L(m)$ defines the image point. This is not yet quite enough to satisfy UP but the additional details [L116] are not needed in the sequel.

The 6-D brane-like special solutions in M^8 are of special interest in the TGD inspired theory of consciousness. They have an M^4 projection which is $E = E_n$ 3-ball. Here E_n is a root of the real polynomial P defining $X^4 \subset M^8$ (M^8 is complexified to M^8_c) as a "root" of its octonionic continuation [L90, L91]. E_n has an interpretation as energy, which can be complex. The original interpretation was as moment of time. For this interpretation, $M^8 - H$ duality would be a linear identification and these hyper planes would be mapped to hyperplanes in $M^4 \subset H$. This motivated the term "very special moment in the life of self" for the image of the $E = E_n$ section of $X^4 \subset M^8$ [L86]. This notion does not make sense at the level M^8 anymore.

The modified $M^8 - H$ duality forces us to modify the original interpretation [L116]. The point $(E_n, p = 0)$ is mapped $(t_n = \hbar_{eff}/E_n, 0)$. The momenta (E_n, p) in $E = E_n$ plane are mapped to the boundary of cd and correspond to a continuous time interval at the boundary of CD: "very special moment" becomes a "very special time interval".

The quantum state however corresponds to a set of points corresponding to quark momenta, which belong to a cognitive representation and are therefore algebraic integers in the extension determined by the polynomial. These active points in E_n are mapped to a discrete set at the boundary of cd(m). A "very special moment" is replaced with a sequence of "very special moments".

So called Galois confinement [L101] forces the total momenta for bound states of quarks and antiquarks to be rational integers invariant under Galois group of extension of rationals determined by the polynomial P [L116]. These states correspond to states at boundaries of sub-CDs so that one obtains a hierarchy. Galois confinement provides a universal number theoretic mechanism for the formation of bound states.

A-7 Zero energy ontology (ZEO)

ZEO is implied by the holography forced in the TGD framework by general coordinate invariance.

A-7.1 Basic motivations and ideas of ZEO

The following gives a brief summary of ZEO [L89] [K146].

- (a) In ZEO quantum states are not 3-dimensional but superpositions of 4-dimensional deterministic time evolutions connecting ordinary initial 3-dimensional states. By holography they are equivalent to pairs of ordinary 3-D states identified as initial and final states of time evolution. One can say that in the TGD framework general coordinate invariance implies holography and the slight failure of its determinism in turn forces ZEO.

Quantum jumps replace this state with a new one: a superposition of deterministic time evolutions is replaced with a new superposition. Classical determinism of individual time evolution is not violated and this solves the basic paradox of quantum measurement theory. There are two kinds of quantum jumps: ordinary ("big") state function reductions (BSFRs) changing the arrow of time and "small" state function reductions (SSFRs) (weak measurements) preserving it and giving rise to the analog of Zeno effect [L89].

- (b) To avoid getting totally confused it is good to emphasize some aspects of ZEO.
- i. ZEO does not mean that physical states in the usual 3-D sense as snapshots of time evolution would have zero energy state pairs defining zero energy states as initial and final states have same conserved quantities such as energy. Conservation implies that one can adopt the conventions that the values of conserved quantities are opposite for these states so that their sum vanishes: one can think that incoming and outgoing particles come from geometric past and future is the picture used in quantum field theories.
 - ii. ZEO means two times: subjective time as sequence of quantum jumps and geometric time as space-time coordinate. These times are identifiable but are strongly correlated.
- (c) In BSFRs the arrow of time is changed and the time evolution in the final state occurs backwards with respect to the time of the external observer. BSFRs can occur in all scales since TGD predicts a hierarchy of effective Planck constants with arbitrarily large values. There is empirical support for BSFRs.
- i. The findings of Mineev et al [L82] in atomic scale can be explained by the same mechanism [L82]. In BSFR a final zero energy state as a superposition of classical deterministic time evolutions emerges and for an observer with a standard arrow of time looks like a superposition of deterministic smooth time evolutions leading to the final state. Interestingly, once this evolution has started, it cannot be stopped unless one changes the stimulus signal inducing the evolution in which case the process does not lead to anywhere: the interpretation would be that BSFR back to the initial state occurs!
 - ii. Libets' experiments about active aspects of consciousness [J23] can be understood. Subject person raises his finger and neural activity starts before the conscious decision to do so. In the physicalistic framework it is thought to lead to raising of the finger. The problem with the explanation is that the activity beginning .5 seconds earlier seems to be dissipation with a reversed arrow of time: from chaotic and disordered to ordered at around .15 seconds. ZEO explanation is that macroscopic quantum jump occurred and generated a signal proceeding backwards in time and generated neural activity and dissipated to randomness.
 - iii. Earthquakes involve a strange anomaly: they are preceded by ELF radiation. One would expect that they generate ELF radiation. The identification as BSFR would explain the anomaly [L84]. In biology the reversal of the arrow of time would occur routinely and be a central element of biological self-organization, in particular self-organized quantum criticality (see [L87, L170]).

A-7.2 Some implications of ZEO

ZEO has profound implications for understanding self-organization and self-organized quantum criticality in terms of dissipation with non-standard arrow of time looking like generation of structures [L87, L170]. ZEO could also allow understanding of what planned actions - like realizing the experiment under consideration - could be.

- (a) Second law in the standard sense does not favor - perhaps even not allow - realization of planned actions. ZEO forces a generalization of thermodynamics: dissipation with a non-standard arrow of time for a subsystem would look like self-organization and planned action and its realization.

Could most if not all planned action be like this - induced by BSFR in the geometric future and only apparently planned? There would be however the experience of planning and realizing induced by the signals from geometric future by a higher level in the hierarchy of conscious entities predicted by TGD! In long time scales we would be realizing our fates or wishes of higher level conscious entities rather than agents with completely free will.

- (b) The notion of magnetic body (MB) serving as a boss of ordinary matter would be central. MB carries dark matter as $h_{eff} = nh_0$ phases of ordinary matter with n serving as a measure for algebraic complexity of extension of rationals as its dimension and defining a kind of universal IQ. There is a hierarchy of these phases and MBs labelled by extension of rationals and the value of n .

MBs would form a hierarchy of bosses - a realization for master slave hierarchy. Ordinary matter would be at the bottom and its coherent behavior would be induced from quantum coherence at higher levels. BSFR for higher level MB would give rise to what looks like planned actions and experienced as planned action at the lower levels of hierarchy. One could speak of planned actions inducing a cascade of planned actions in shorter time scales and eventually proceeding to atomic level.

A-8 Some notions relevant to TGD inspired consciousness and quantum biology

Below some notions relevant to TGD inspired theory of consciousness and quantum biology.

A-8.1 The notion of magnetic body

Topological field quantization inspires the notion of field body about which magnetic body is especially important example and plays key role in TGD inspired quantum biology and consciousness theory. This is a crucial departure from the Maxwellian view. Magnetic body brings in third level to the description of living system as a system interacting strongly with environment. Magnetic body would serve as an intentional agent using biological body as a motor instrument and sensory receptor. EEG would communicate the information from biological body to magnetic body and Libet's findings from time delays of consciousness support this view.

The following pictures illustrate the notion of magnetic body and its dynamics relevant for quantum biology in TGD Universe.

Fig. 18. Magnetic body associated with dipole field. <http://tgdtheory.fi/appfigures/fluxquant.jpg>

Fig. 19. Illustration of the reconnection by magnetic flux loops. <http://tgdtheory.fi/appfigures/reconnect1.jpg>

Fig. 20. Illustration of the reconnection by flux tubes connecting pairs of molecules. <http://tgdtheory.fi/appfigures/reconnect2.jpg>

Fig. 21. Flux tube dynamics. a) Reconnection making possible magnetic body to “recognize” the presence of another magnetic body, b) braiding, knotting and linking of flux tubes making possible topological quantum computation, c) contraction of flux tube in phase transition reducing the value of h_{eff} allowing two molecules to find each other in dense molecular soup. <http://tgdtheory.fi/appfigures/fluxtubedynamics.jpg>

A-8.2 Number theoretic entropy and negentropic entanglement

TGD inspired theory of consciousness relies heavily p-Adic norm allows an to define the notion of Shannon entropy for rational probabilities (and even those in algebraic extension of rationals) by replacing the argument of logarithm of probability with its p-adic norm. The resulting entropy can be negative and the interpretation is that number theoretic entanglement entropy defined by this formula for the p-adic prime minimizing its value serves as a measure for conscious information. This negentropy characterizes two-particle system and has nothing to do with the formal negative negentropy assignable to thermodynamic entropy characterizing single particle. Negentropy Maximization Principle (NMP) implies that number theoretic negentropy increases during evolution by quantum jumps. The condition that NMP is consistent with the standard quantum measurement theory requires that negentropic entanglement has a density matrix proportional to unit matrix so that in 2-particle case the entanglement matrix is unitary.

Fig. 22. Schrödinger cat is neither dead or alive. For negentropic entanglement this state would be stable. <http://tgdtheory.fi/appfigures/cat.jpg>

A-8.3 Life as something residing in the intersection of reality and p-adicities

In TGD inspired theory of consciousness p-adic space-time sheets correspond to space-time correlates for thoughts and intentions. The intersections of real and p-adic preferred extremals consist of points whose coordinates are rational or belong to some extension of rational numbers in preferred embedding space coordinates. They would correspond to the intersection of reality and various p-adicities representing the “mind stuff” of Descartes. There is temptation to assign life to the intersection of realities and p-adicities. The discretization of the chart map assigning to real space-time surface its p-adic counterpart would reflect finite cognitive resolution.

At the level of “world of classical worlds” (WCW) the intersection of reality and various p-adicities would correspond to space-time surfaces (or possibly partonic 2-surfaces) representable in terms of rational functions with polynomial coefficients with are rational or belong to algebraic extension of rationals.

The quantum jump replacing real space-time sheet with p-adic one (vice versa) would correspond to a buildup of cognitive representation (realization of intentional action).

Fig. 23. The quantum jump replacing real space-time surface with corresponding p-adic manifold can be interpreted as formation of thought, cognitive representation. Its reversal would correspond to a transformation of intention to action. <http://tgdtheory.fi/appfigures/padictoreal.jpg>

A-8.4 Sharing of mental images

The 3-surfaces serving as correlates for sub-selves can topologically condense to disjoint large space-time sheets representing selves. These 3-surfaces can also have flux tube connections

and this makes possible entanglement of sub-selves, which unentangled in the resolution defined by the size of sub-selves. The interpretation for this negentropic entanglement would be in terms of sharing of mental images. This would mean that contents of consciousness are not completely private as assumed in neuroscience.

Fig. 24. Sharing of mental images by entanglement of subselves made possible by flux tube connections between topologically condensed space-time sheets associated with mental images. <http://tgdtheory.fi/appfigures/sharing.jpg>

A-8.5 Time mirror mechanism

Zero energy ontology (ZEO) is crucial part of both TGD and TGD inspired consciousness and leads to the understanding of the relationship between geometric time and experience time and how the arrow of psychological time emerges. One of the basic predictions is the possibility of negative energy signals propagating backwards in geometric time and having the property that entropy basically associated with subjective time grows in reversed direction of geometric time. Negative energy signals inspire time mirror mechanism (see **Fig.** <http://tgdtheory.fi/appfigures/timemirror.jpg> or **Fig. 24** in the appendix of this book) providing mechanisms of both memory recall, realization of intentional action initiating action already in geometric past, and remote metabolism. What happens that negative energy signal travels to past and is reflected as positive energy signal and returns to the sender. This process works also in the reverse time direction.

Fig. 25. Zero energy ontology allows time mirror mechanism as a mechanism of memory recall. Essentially “seeing” in time direction is in question. <http://tgdtheory.fi/appfigures/timemirror.jpg>

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