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TGD BASED VIEW ABOUT LIVING MATTER AND REMOTE MENTAL INTERACTIONS

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April 28, 2024

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 Geometrodynamics (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. ??**). 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 $H = M^4 \times CP_2$ [L156]. 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 [L76, L96](see **Fig. ??**). 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. ??**). The mere mathematical existence of WCW geometry requires that it has maximal isometries, which together twistor lift and number theoretic vision fixes it uniquely [L158].
- 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 [K148, L112].
- 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 [K36, K74] [L144].
- 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 [L150]. 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 [L163].
- 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 theoretical trinity involves besides p-adic number fields also quaternions and octonions and the notion of infinite prime.

Adelic physics [L74, L75] 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 arbitarily 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.** ??). 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 [L160]. 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. ??). 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. ??), 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 Mazimization 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 $h_{eff} = n \times h$ 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. ??**).

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 or 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. ??**).

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 derivates.

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. ??** and **Fig. ??**). 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. ??**). 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 lightcones. 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 spacetime of TGD by lumping together the space-time sheets to a region Minkowski space and endowing it with an effective metric given as a sum of Minkowski metric and deviations of the metrices 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 [L139], 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 massles 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 where replaced with 4-surfaces satifying 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-Univeverses) 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 [A17]. I have proposed [K65, K39, K144, K109, L158] 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 by the partonic orbits for which partonic orbits associated with wormrhole 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 [K148, L112] 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 [L134, L135] 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 infinitedimensional 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 breakthough in the construction of the scattering amplitudes by solving the problem of identifying interaction vertices [L163].

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 expressess masslessness for both fields and particles as 3surfaces. 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 CP₂asalsointheclassicalpicture.
- 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.

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/field 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 undersand 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 [L147]. Quite generally, long range classical gravitational, electric and magnetic fields give rise to very large values of effective Planckl constants. The Nottale's hypothesis of gravitational Planck constant generalizes to electric interactions.

• 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 then.

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.

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 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 anomalies of water lead to a model for dark nuclei as dark proton strings with the surprising prediction that DNA, RNA, aninoacids 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 inspire 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.

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

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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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 [K4].

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 [A27]. 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 nonvanishing 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 $h_{eff}/h = n$ 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] [B13, 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 welldefinedness 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 spacetime 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 $H = M_{\times}^4 CP_2$, where M^4 denotes Minkowski space and $CP_2 = SU(3)/U(2)$ is the complex projective space of two complex dimensions [A20, A26, A15, A24].

The identification of the space-time as a sub-manifold [A21, A36] 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. 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 thins 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 $\sqrt{g_4}$ factorc 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 a 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 HDirac 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 $_DH$ 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 welldefined 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 [A31, A38, A43]. 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 spacetime 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 Smatrix 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 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 biven 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 [K85]. 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 infinitedimensional 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 infinitedimensional 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 a delic 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 quantums 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 reduces 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 padic 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 (imaginations) 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 [K80].

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 3surface. 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 \overline{z} . Any analytic map $u \to f(u)$ 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 $Re(E)^2$.

$$Re(E)^{2} = \frac{1}{2} (Re(m^{2}) - Im(m^{2}) + p^{2})(1 \pm \sqrt{1 + \frac{2Im(m^{2})^{2}}{(Re(m^{2}) - Im(m^{2}) + p^{2})^{2}}} .$$
(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 $Re(E)^2 \to Im(m^2)/\sqrt{2}$ at the low momentum limit $p^2 \to 0$. 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 $M_c^4 \to SU(3)_c \subset G_{2,c}$, 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 $g(x) \subset SU(3) \subset G_2$ 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 subspace 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 o 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 form 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 $1 \oplus 3 \oplus \overline{3}$. The automorphism property requires that 1 can be transformed to 3 or $\overline{3}$ to themselves: this requires that the decomposition contains $3 \oplus \overline{3}$. Furthermore, it must be possible to transform 3 and $\overline{3}$ to themselves, which requires the presence of 8. This leaves only the decomposition $8 \oplus 3 \oplus \overline{3}$. 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 [E1] 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 h_{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 h_{gr} would be much smaller. Large h_{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 [K117].

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 $h_{eff} = n \times = h_{gr}$. The large value of h_{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 $h_{eff}/h = n$ 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 tfermionic oscillator operators generate super-symmetries and sparticles correspond almost by definition to dark matter with $h_{eff}/h = n > 1$. 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 ($E = hf_{high} = h_{eff}f_{low}$) 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 [K100, K101, K98]) 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 biochemistry 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 [K132]. 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 [A27]. 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 co-incides 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 spacetime 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 [L94].

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 [L75]. 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/yyhwvbqb) was Veneziano duality. This 4-particle amplitude was generalized by Yoshiro Nambu, Holber-Beck 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 tchannel 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 with.

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 algebrable (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 [K131, K25, K97, K23, K60, K71, K75, K120, K129].

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

$$\Psi_i \to U \Psi_i \to \Psi_f$$

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 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 $Tr[S^{-n_1} \circ H^i H^j \circ S^{n_2} \lambda]$, 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 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 preparated 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 Fantappie [J82] 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 reduce 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 ($\delta M_+^4 \times CP_2$).

- 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 start 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) [K80] 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 generalizes 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 generates 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 large 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 it 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 [K108]. 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 so 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, ... p-Adic regions obey the same field equations as the real regions but are characterized by p-adic nondeterminism 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 pinary 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 [K125]. The application 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 pinary digits a p-valued logic but as such this kind of logic does not have any reasonable identification. p-Adic length scale hypothesis suggest that the $p = 2^k - n$ pinary 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 [K48].

Dark matter hierarchy leads to detailed quantitative view about quantum biology with several testable predictions [K48]. 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 [K48]. Also a generalization of the notion of genetic code emerges resolving the paradoxes related to the standard dogma [K73, K48]. A particularly fascinating implication is the possibility

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to identify great leaps in evolution as phase transitions in which new higher level of dark matter emerges [K48].

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 [K47, K48]. 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 experiences subselves 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 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 [K48]. 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 [K73, K48]. In fact, higher levels of dark matter hierarchy motivate the introduction of the notions of supergenome 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 inspire 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/field 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 undersand 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 then.

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 massess 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, anino-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.

1.4 Motivations for "TGD Based View About Living Matter and Remote Mental Interactions"

The latest TGD inspired articles related to quantum biology, quantum mind, and remote mental interactions were published in JNLRMI around 2003. Several new ideas related to basic TGD, TGD inspired quantum biology and theory of consciousness have emerged during the subsequent 8 years: for a short summary about the development of ideas see the article [L21].

My original intention was to write just single article trying to give a summary about the progress of quantum TGD first and after that I will discuss the implications for quantum TGD based view about biology, consciousness and remote mental interactions and similar anomalies.

As usually happens, also now I realized that I am not able to write this kind of short article. The amount of topics has grown during years quite large and is scattered around to several books and gradually I began to feel desperate. I simply could not decide what should I take and what should I leave. Finally I drifted to the predictable outcome: I decided to wrote several articles with topic restricted to the recent state of quantum TGD itself, TGD inspired views about consciousness, and some basic aspects of biology, neuroscience, and remote mental interactions. The decision was made easy after recalling that I had written a series of three articles to the journal Journal of Consciousness Exploration and Research founded by Huping Hu. It was rather easy to add the developments that had happened during last three years to these articles and write a new article about remote mental interactions and about testing the vision. The final step was the realization that it is natural to organize the article in a form of book.

There are other arguments in defence of book format. For a long time the basic challenge of TGD has been to give a precise meaning for heuristic ideas and loosely formulated concepts. Why this kind of approach requiring scanning through of all what one has written is so fruitful is that it forces to realize that definitions which have seemed obvious, are not at all obvious after all. At this stage when so little is known, internal consistency is an extremely valuable constraint on free imagination. Although reprocessing all this topic requires patience, it helps so identify internal inconsistencies. There has been quite a flux of ideas during last years and it is also very useful to allow them to interact.

Therefore the outcome was six articles transformed into chapters of a book. The reader should not be scared. I have tried to write these chapters so that one could read them in any order and there are links to the material at my homepage.

Later I have written many new chapters so that the total page number grew so large that I decided to divide the book into two pieces. In part I I have discussed TGD inspired visions about consciousness and quantum biology. In part II about TGD based views about neuroscience and remote mental interactions are represented. I however kept also the version without division.

1.4.1 Topics of "TGD Based View About Living Matter and Remote Mental Interactions: Part I"

The book consists of 2 parts.

- 1. The 1st part of the book contains one chapter about TGD itself and two chapters about TGD inspired theory of consciousness. The remaining two chapters are devoted to a comparison with some other theories of consciousness, in particular the integrated information theory of consciousness (IIT) by Tononi and Koch.
- 2. In 2nd part TGD inspired quantum biology is discussed at general level. The notion of magnetic body (MB) carrying dark matter is introduced first. There are two chapters about the role of dark photons as source of bio-photons. The notion of remote metabolism inspired by zero energy ontology (ZEO) is discussed in one chapter. There is a chapter about the necessity of new quantum physics in living systems. Two remaining chapters are devoted to applications.

1.5 Sources

The eight online books about TGD [K141, K133, K107, K89, K30, K86, K63, K121] and nine online books about TGD inspired theory of consciousness and quantum biology [K131, K25, K97, K23, K60, K71, K75, K120, K129] 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.

1.6 The contents of the book

1.6.1 PART I: TGD INSPIRED THEORY OF CONSCIOUSNESS

Topological Geometrodynamics: Basic Visions

In this article I will discuss three basic visions about quantum Topological Geometrodynamics (TGD). It is somewhat matter of taste which idea one should call a vision and the selection of these three in a special role is what I feel natural just now.

- 1. The first vision is generalization of Einstein's geometrization program based on the idea that the Kähler geometry of the world of classical worlds (WCW) with physical states identified as classical spinor fields on this space would provide the ultimate formulation of physics.
- 2. Second vision is number theoretical and involves three threads. The first thread relies on the idea that it should be possible to fuse real number based physics and physics associated with various p-adic number fields to single coherent whole by a proper generalization of number concept. Second thread is based on the hypothesis that classical number fields could allow to understand the fundamental symmetries of physics and and imply quantum TGD from purely number theoretical premises with associativity defining the fundamental dynamical principle both classically and quantum mechanically. The third threadrelies on the notion of infinite primes whose construction has amazing structural similarities with second quantization of super-symmetric quantum field theories. In particular, the hierarchy of infinite primes and integers allows to generalize the notion of numbers so that given real number has infinitely rich number theoretic anatomy based on the existence of infinite number of real units.
- 3. The third vision is based on TGD inspired theory of consciousness, which can be regarded as an extension of quantum measurement theory to a theory of consciousness raising observer from an outsider to a key actor of quantum physics.

The basic aspects of quantum classical correspondence are discussed. Strong form of General Coordinate Invariance implies strong form of holography and effective 2-dimensionality. Weak form of electric magnetic duality and simple general condition on preferred extremals of Kähler action imply that TGD indeed reduces to almost topological QFT defined by Chern-Simons terms located at space-like at ends of *CDs* and light-like 3-surfaces defined by the orbits of partonic 2-surfaces defining wormhole throats at which the signature of induced metric changes. A further reduction of action to sum of areas of minimal surfaces is conjectured on basis of effective 2-dimensionality. Feynman diagrams have direct interpretation in terms of space-time topology and ZEO leads to a dramatic simplification of the Feynman diagrammatics and suggest a close connection with twistorial diagrams. Induced gauge field concept makes impossible the superposition of classical fields in TGD Universe. This is a grave objection circumvented by simple observation: only the superposition of their effects is observed and many-sheeted space-time implies it.

Quantum Mind in TGD Universe

The basic difficulties and challenges of Quantum Mind program are analyzed. The conclusion is that the recent form of quantum theory is not enough to overcome the challenges posed by the philosophical problems of quantum physics and quantum mind theories, and the puzzles of quantum biology and quantum neuroscience. Certain anomalies of recent day biology giving hints about how quantum theory should be generalized serve as an introduction to the summary of the aspects of quantum TGD especially relevant to the notion of Quantum Mind. These include the notions of many-sheeted space-time and field (magnetic) body, zero energy ontology, the identification dark matter as a hierarchy of phases with large value of Planck constant, and p-adic physics proposed to define physical correlates for cognition and intentionality.

Especially relevant is the number theoretic generalization of Shannon entropy: this entropy is well defined for rational or even algebraic entanglement probabilities and its minimum as a function of the prime defining p-adic norm appearing in the definition of the entropy is negative. Therefore the notion of negentropic entanglement makes sense in the intersection of real and p-adic worlds and is negative: this motivates the proposal that living matter resides in this intersection. TGD inspired theory of consciousness is introduced as a generalization of quantum measurement theory. The notions of quantum jump and self defining the generalization of the notion of observer are introduced and it is argued that the notion of self reduces to that for quantum jump. Negentropy Maximization Principle reproduces standard quantum measurement theory for ordinary entanglement but respects negentropic entanglement so that the outcome of state function reduction is not random for negentropic entanglement. The new view about the relationship of experienced time and geometric time combined with zero energy ontology is claimed to solve the basic philosophical difficulties of quantum measurement theory and consciousness theory. The identification of the quantum correlates of sensory qualia and Boolean cognition, emotions, cognition and intentionality and self-referentiality of consciousness is discussed.

Life and Death and Consciousness

Life and death belong to the greatest mysteries of science. The development of quantum theories of consciousness has made possible to say something non-trivial also about life and death. In this article I describe TGD inspired theory of consciousness and the view that it provides about life and death. There are several notions which are new from the point of view of standard physics. From the point of view of TGD inspired theory of consciousness the most important ones are Zero Energy Ontology (ZEO), Causal Diamond (CD), Negentropy Maximization Principle (NMP). One can say that self as conscious entity is a sequence of repeated state function reductions at the same boundary of CD and not affecting or states at it - Zeno effect- and that self dies as the first reduction to the opposite boundary of CD is forced by NMP and means reincarnation of self as time-reversed self.

From the point of view of TGD inspired quantum biology the identification of dark matter has $h_{eff}/h = n$ phases of ordinary matter having non-standard value of Planck constant is central: these phases allow to understand living matter as macroscopically quantum coherent phases. Second key notion is that of field body, in particular magnetic body. This is implied by TGD view about space-time as 4-D surface of certain 8-D space-time and means that physical systems have besides ordinary identify also field identity so that one can talk about magnetic body (MB). MB takes the role of intentional agent using biological body as motor instrument and sensory receptor: this for instance explains EEG as a communications and control tool.

Comparison of TGD Inspired Theory of Consciousness with Some Other Theories of Consciousness

This work has been inspired by two books. The first book "On intelligence" is by Jeff Hawkins. The second book "Consciousness: the science of subjectivity" is by Antti Revonsuo.

Jeff Hawkins has developed a highly interesting and inspiring vision about neo-cortex, one of the few serious attempts to build a unified view about what brain does and how it does it. Since key ideas of Hawkins have quantum analogs in TGD framework, there is high motivation for developing a quantum variant of this vision. The vision of Hawkins is very general in the sense that all parts of neo-cortex would run the same fundamental algorithm, which is essentially checking whether the sensory input can be interpreted in terms of standard mental images stored as memories. This process occurs at several abstraction levels and involve massive feedback. If it succeeds at all these levels the sensory input is fully understood.

TGD suggests a generalization of this process. Quantum jump as a moment of consciousness and a sequence of quantum jumps inducing repeated state function reduction at the same boundary of causal diamond (CD) as self would be the basic identifications. These would define the fundamental algorithm realized in all scales defining an abstraction hierarchy. Negentropy Maximization Principle (NMP) would be the variational principle driving this process and in optimal case lead to an experience of understanding at all levels of the scale hierarchy realized in terms of generation of negentropic entanglement. The analogy of NMP with second law suggests strongly thermodynamical analogy and p-adic thermodynamics used in particle mass calculations might be also seen as effective thermodynamics assignable to NMP.

In the following I will first discuss the ideas of Hawkins and then summarize some relevant aspects of quantum TGD and TGD inspired theory of consciousness briefly in the hope that this could make representation comprehensible for the reader having no background in TGD (I hope I have achieved this). The representation involves some new elements: reduction of the old idea about motor action as time reversal of sensory perception to the anatomy of quantum jump sequence in zero energy ontology (ZEO); interaction free measurement for photons and photons as a nondestructive reading mechanism of memories and future plans (time reversed memories) represented 4-dimensionally as negentropically entangled states approximately invariant under quantum jumps (this resolves a basic objection against identifying quantum jump as moment of consciousness) leading to the identification of analogs of imagination and internal speech as fundamental elements of cognition; and a more detailed quantum model for association and abstraction processes.

I will also compare various theories and philosophies of consciousness with TGD approach following the beautifully organized representation of Revonsuo. Also anomalies of consciousness are briefly discussed. My hope is that this comparison would make explicit that TGD based ontology of consciousness indeed circumvents the difficulties against monistic and dualistic approaches and also survives the basic objections that I have been able to invent hitherto.

TGD Inspired Comments about Integrated Information Theory of Consciousness

Integrated Information Theory (IIT) is a theory of consciousness originally proposed by Giulio Tononi. The basic goal of IIT is to abstract from neuroscience axioms about consciousness hoped to provide constraints on physical models. IIT relies strongly on information theory. The basic problem is that the very definition of information is not possible without introducing conscious observer so that circularity cannot be avoided. IIT identifies a collection of few basic concepts and axioms such as the notions of mechanism (computer program is one analog for mechanism), information, integration and maximally integrated information (maximal interdependence of parts of the system), and exclusion. Also the composition of mechanisms as kind of engineering principle of consciousness is assumed and leads to the notion of conceptual structure, which should allow to understand not only cognition but entire conscious experience.

A measure for integrated information (called Φ) assignable to any partition of system to two parts is introduced in terms of relative entropies. Consciousness is identified with a maximally integrated decomposition of the system to two parts (Φ is maximum). The existence of this preferred decomposition of the system to two parts besides computer and program running in it distinguishes IIT from the computational approach to consciousness. Personally I am however afraid that bringing in physics could bring in physicalism and reduce consciousness to an epiphenomenon. Qualia are assigned to the links of network. IIT can be criticized for this assignment as also for the fact that it does not say much about free will nor about the notion of time. Also the principle fixing the dynamics of consciousness is missing unless one interprets mechanisms as such.

In this article IIT is compared to the TGD vision relying on physics and on general vision about consciousness strongly guided by the new physics predicted by TGD. At classical level this new physics involves a new view about space-time and fields (in particular the notion of magnetic body central in TGD inspired quantum biology and quantum neuroscience). At quantum level it involves Zero Energy Ontology (ZEO) and the notion of causal diamond (CD) defining 4-D perceptive field of self; p-adic physics as physics of cognition and imagination and the fusion of real and various p-adic physics to adelic physics; strong form of holography (SH) implying that 2-D string world sheets and partonic surfaces serve as "space-time genes"; and the hierarchy of Planck constants making possible macroscopic quantum coherence.

Number theoretic entanglement entropy (EE) makes sense as number theoretic variant of Shannon entropy in the p-adic sectors of the adelic Universe. Number theoretic EE can be negative and corresponds in this case to genuine information: one has negentropic entanglement (NE). TGD inspired theory of consciousness reduces to quantum measurement theory in ZEO. Negentropy Maximization Principle (NMP) serves as the variational principle of consciousness and implies that NE can can only increase - this implies evolution. By SH real and p-adic 4-D systems are algebraic continuations of 2-D systems ("space-time genes") characterized by algebraic extensions of rationals labelling evolutionary levels with increasing algebraic complexity. Real and p-adic sectors have common Hilbert space with coefficients in algebraic extension of rationals so that the state function reduction at this level can be said to induce real and p-adic 4-D reductions as its shadows.

NE in the p-adic sectors stabilizes the entanglement also in real sector (the sum of real (ordinary) and various p-adic negentropies tends to increase) - the randomness of the ordinary

state function reduction is tamed by cognition and mind can be said to rule over matter. Quale corresponds in IIT to a link of a network like structure. In TGD quale corresponds to the eigenvalues of observables measured repeatedly as long as corresponding sub-self (mental image, quale) remains conscious.

In ZEO self can be seen as a generalized Zeno effect. What happens in death of a conscious entity (self) can be understood and it accompanies re-incarnation of time reversed self in turn making possible re-incarnation also in the more conventional sense of the word. The death of mental image (sub-self) can be also interpreted as motor action involving signal to geometric past: this in accordance with Libet's findings.

There is much common between IIT and TGD at general structural level but also profound differences. Also TGD predicts restricted pan-psychism. NE is the TGD counterpart for the integrated information. The combinational structure of NE gives rise to quantal complexity. Mechanisms correspond to 4-D self-organization patterns with self-organization interpreted in 4-D sense in ZEO. The decomposition of system to two parts such that this decomposition can give rise to a maximal negentropy gain in state function reduction is also involved but yields two independent selves. Engineering of conscious systems from simpler basic building blocks is predicted. Indeed, TGD predicts infinite self hierarchy with sub-selves identifiable as mental images. Exclusion postulate is not needed in TGD framework. Also network like structures emerge naturally as p-adic systems for which all decompositions are negentropically entangled inducing in turn corresponding real systems.

1.6.2 PART II: QUANTUM BIOLOGY IN TGD UNIVERSE

Quantum Mind, Magnetic Body, and Biological Body

The chapter is devoted to some applications of TGD inspired view about Quantum Mind to biology. Magnetic body carrying dark matter and forming an onionlike structure with layers characterized by large values of Planck constant is the key concept. Magnetic body is identified as intentional agent using biological body as sensory receptor and motor instrument. EEG is 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 then. 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.

A vision about quantum metabolism in TGD Universe is proposed. The new element is the idea that the presence of ATP at magnetic flux tube is a necessary prerequisite for negentropic entanglement between its ends. ATP could be seen as a molecule of consciousness in this picture. Also a possible modification of second law to take into account negentropic entanglement is discussed. 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. These findings are briefly discussed in TGD framework by bringing in magnetic flux tubes as a new element. Water is in key role in living matter and TGD inspired view about water and its anomalies is discussed.

Are dark photons behind bio-photons?

TGD approach leads to a prediction that bio-photons result when dark photons with large value of effective Planck constant and large wavelength transform to ordinary photons with same energy. The recent progress in understanding the implications of basic vision behind TGD inspired theory of consciousness served as a particular motivation for developing a more detailed view about bio-photons.

- 1. The anatomy of quantum jump in zero energy ontology (ZEO) allows one to understand basic aspects of sensory and cognitive processing in the brain without ever mentioning the brain. Sensory perception - motor action cycle with motor action interpreted as time-reversed sensory perception directly reflects the fact that state function reductions occur as sequences to the same boundary of causal diamond (CD) (which itself or rather, quantum superposition of CDs, changes in the process such that either the upper or lower boundaries of all CDs involved are localized at the same light-cone boundary). The first reduction of sequence corresponds to genuine state function reduction and the next induce changes only at the second boundary giving rise to experience flow of time and arrow of time.
- 2. Also the abstraction and de-abstraction processes in various scales which are essential for neural processing emerge already at the level of quantum jump. The formation of associations is one aspect of abstraction since it combines different manners to experience the same object. Negentropic entanglement of two or more mental images (CDs) gives rise to rules in which superposed *n*-particle states correspond to instances of the rule or association of *n* events. Schrödinger cat serves as an example: the superposition of living cat-closed bottle and dead-cat-open bottle gives a quantum representation for the rule that it is not good idea to open the bottle. Cat attending to/quantum entangling with the bottle is conscious about the rule. Tensor product formation generating negentropic entanglement between new mental images and earlier ones generates longer sequences of memory mental images and gives rise to negentropy gain generating experience of understanding, recognition, something which has positive emotional coloring. Quantum superposition of perceptively equivalent zero energy states in given resolution gives rise to averaging. Increasing the abstraction level means poorer resolution so that the insignificant details are not perceived.
- 3. Various memory representations should be approximately invariant under the sequence of quantum jumps. Negentropic entanglement gives rise to this kind of stabilization. The assumption that self model is a negentropically entangled system which does not change in state function reduction, leads to a problem. If the conscious information about this kind of subself corresponds to change of negentropy in quantum jump, it seems impossible to get this information. Quite generally, if moment of consciousness corresponds to quantum jump and thus *change*, how is it possible to carry conscious information about *quantum state*? Interaction free measurement however allows to circumvent the problem: non-destructive reading of memories and future plans becomes possible in arbitrary good approximation.

This memory reading mechanism can be formulated for both photons and phonons and these two reading mechanisms could correspond to visual memories as imagination and auditory memories as internal speech. Therefore dark photons decaying to bio-photons could be crucial element of imagination. The notion of bio-phonon could also make sense and even follow as a prediction. The identification of dark photons responsible for the reading of memories with EEG is suggested by the strong correlation of latter with the contents consciousness. This would also suggest a correlation of bio-photon emission with EEG for which there is a considerable evidence. The indications that bio-photons are associated only with the right hemisphere suggests that at least some parts of right hemisphere prefer dark photons and are thus specialized to visual imagination: spatial relationships are the speciality of the right hemisphere. Some parts the of left hemisphere at least might prefer dark photons in IR energy range transforming to ordinary phonons in ear or dark phonons: left hemisphere is indeed the verbal hemisphere specialized to linear linguistic cognition.

4. After the writing of the original version of the chapter it turned out that there are good justifications for the proposal that the energy spectrum of dark photons might be universal and do not depend on the mass of the charged particle. This requires that h_{eff} is proportional to the mass of the charged particle. This conforms with the hypothesis that bio-photons result in the transformation of dark photons to ordinary photons and the hypothesis cyclotron frequencies code serve as kind of passwords characterizing the ion. Dark ions could also affect ordinary matter by inducing molecular transitions in visible and UV ranbge by transforming first to bio-photons.

In the following I shall discuss bio-photons in TGD Universe as decay products of dark

photons and propose among other things an explanation for the hyperbolic decay law in terms of quantum coherence and echo-like mechanism guaranteeing replication of memory representations. Applications to biology, neuroscience, and consciousness are discussed and also the possible role of bio-photons for remote mental interactions is considered. Also the phenomenon of Taos hum is discussed as a possible evidence for biophonons.

Dark valence electrons, dark photons, bio-photons, and carcinogens

The possible role of bio-photons in living matter is becoming gradually accepted by biologists and neuroscientists. Bio-photons serve as a diagnostic tool and it seems that their intensity increases in non-healthy organism. I have proposed that bio-photons emerge from what I call dark photons, which are ordinary photons but have non-standard value $h_{eff} = nh_0$ of Planck constant.

In this article the consequences of the hypothesis that dark photons emerging from the transitions of dark valence electrons of any atom possessing lonely unpaired valence electron could give rise to part of bio-photons in they decays to ordinary photons. The hypothesis is developed by considering a TGD based model for a finding, which served as a starting point of the work of Popp: the irradiation of carcinogens with light at wavelength of 380 nm generates radiation with wavelength 218 nm so that the energy of the photon increases in the interaction. Also the findings of Veljkovic about the absorption spectrum of carcinogens have considerably helped in the development of the model.

The outcome is a proposal for dark transitions explaining the findings of Popp and Veljkovic. The spectrum of dark photons also suggests a possible identification of metabolic energy quantum of .5 eV and of the Coulomb energy assignable to the cell membrane potential. The possible contribution to the spectrum of bio-photons is considered, and it is found that spectrum differs from a smooth spectrum since the ionization energies for dark valence electrons depending on the value of h_{eff} as $1/h_{eff}^2$ serve as accumulation points for the spectral lines. Also the possible connections with TGD based models of color vision and of music harmony are briefly discussed.

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.

Can quantum biology really do without new physics?

Quantum biology is now taken rather seriously. Photosynthesis and avian navigation are two key applications of quantum biology. The basic problem in both cases is posed by the fact that the magnetic interaction energy in Earth's magnetic field is roughly million times smaller than thermal energy. The so called radical-pair mechanism (RPM) was proposed already at 60's as a possible solution to the problem posed by anomalously large effect in EPR and NMR experiments. According to RPM, a radical pair is accompanied by electron pair, which is in a superposition of spin triplet and singlet states and behaves as quantum coherent system for a time sufficiently long to induce chemical effects. The hyperfine interaction of the members of the electron pair with the nuclei of radicals would amplify the effect. The neutralization of radical pair puts an end to the coherence interaction period.

The proposal is that RPM gives rise to chemical compass making possible avian navigation. There is however a problem. RPM has been observed in laboratory only for magnetic fields in the range 1 mT- 10 T. Earth's magnetic field is only 2 per cent of the lower bound so that it is quite possible that RPM is not at work.

This opens up the door for new quantum physics proposed by TGD based model of quantum biology. In this approach magnetic body acts as as intentional agent using biological body as a sensory receptor and motor instrument. Macroscopic quantum coherence is made possible by dark matter realized as a hierarchy of $h_{eff} = n \times h$ phases.

In this chapter RMP is summarized and compared with the TGD based vision. Also the possible connection between avian navigation and circadian clock suggested by the fact that both involve photoreceptor known as cryptocrome and a possible connection with gravitaxis are considered in TGD framework.

The anomalies in rotating magnetic systems as a key to the understanding of morphogenesis?

During almost two decades I have returned repeatedly to the fascinating but unfortunately unrecognized work of Roschin and Godin about rotating magnetic systems. With the recent advances in TGD it has become clear that the reported strange effects such as the change of weight proportional to the rotation velocity of rollers taking place above 3.3 Hz rotation frequency and rapid acceleration above 9.2 Hz up to frequency 10 Hz could provide clues for developing a general vision about morphogenesis of magnetic body, whose flux quanta can carry Bose-Einstein condensates of dark charged ions with given mass and charge if the hypothesis $h_{eff} = n \times h = h_{gr}$ identifying dark matter as phases with non-standard value of Planck constant holds true.

The generalization of Chladni mechanism would provide a general model for how magnetic flux tubes carrying charged particles with given mass at given flux tube drift to the nodal surfaces giving rise to magnetic walls in the field of standing or even propagating waves assignable to "topological light rays" (MEs). Ordinary matter would in turn condense around these dark magnetic structures so that Chladni mechanism would serve as a general mechanism of morphogenesis. This mechanism could be universal and work even in astrophysical systems (formation of planets).

The change of weight correlating with the direction of rotation (parity breaking) and rapid acceleration could be understood in terms of momentum and angular momentum transfer by dark photons liberated in the quantum phase transition of many-particle states of dark charged particles to from cyclotron Bose-Einstein condensates giving rise to analogs of superconductivity and spontaneous magnetization.

There is also evidence that the presence of light source below massive object affects its weight by about .1 per cent. This effect could be explained along the same lines. Zero Energy Ontology and the proposed mechanism remote metabolism at the level of dark matter is however needed and this would force to modify dramatically the views about basic interactions at the level of dark matter.

An increase of weight $\Delta g/g \simeq 2 \times 10^{-4}$ is observed for electrets: this number has appeared in TGD already earlier and in TGD framework could have interpretatation in terms of dark matter layer with mass $M^D \simeq 2 \times 10^{-4} M_E$ at distance of Moon. More generally, any living system could be accompanied by a magnetic body with this mass fraction and lose it in biological death. Amusingly, this change of weight happens to consistent with the "weight of soul" claimed to be 21 g.

Life-like properties observed in very simple systems

The physicists working in Emory University have made very interesting discovery. The very simple system studied exhibits what authors call self-organized bi-stability making phase transitions between crystal-like and gas-like phases. The expectation was that only single stable state would appear. Neuron groups can also have collective bi-stability (periodic synchronous firing). Neurons are however themselves bi-stable systems: now the particles are plastic balls and are not bi-stable. One could say that the system exhibits life-like properties. The most remarkable life-like property is metabolism required by the sequence of phase transitions involving dissipation.

Where does the metabolic energy come from? The proposal of the experimenters that stochastic resonance feeds the needed metabolic energy leaves open its source. The resemblance with living cells suggests that the attempt to interpret the findings solely in terms of non-equilibrium thermodynamics might miss something essential - the metabolism.

One can develop a model for the system based on TGD inpired quantum biology. This involves the notion of magnetic body carrying dark matter identified as $h_{eff} = n \times h$ phases; a network of magnetic flux tubes (magnetic body) controlling biological body (now charged plastic balls) and responsible for coherence and synchrony (of the crystal-like phase now); the control of the oscillations of BB by cyclotron radiation (now the plastic ball system) resulting from decays of cyclotron condensates of charged particles (now protons and Ar ions). The source of metabolic energy would come from dark nucleosynthesis explaining nuclear transmutations occurring in living matter and "cold fusion" and serving as source of metabolic energy in prebiotic stage when the chemical energy storage had not yet emerged. Dark analogs of DNA, RNA, tRNA, and amino-acids are dark protons sequences realizing degeneracies of vertebrate genetic code are dark nuclei and can transform to ordinary nuclei and liberate nuclear binding energy so that the hen-egg question about which came first: metabolism or genetic code, is resolved: hen= egg.

There is also second very simple system consisting of particle system with feed of acoustic energy at single wavelength. What happens that the distribution of particles develops synchronous oscillations in wave length band. and the amplitudes are reduced in this band so that wavelength gap emerges. The system is also able to heal. The interpretation is in terms of the emergence of flux tube structure rigidifying the system to pseudo-crystal. The energy of the oscillations of the particles is transferred to MB where it gives rise to Alfwen waves with a wavelength band analogous to atomic energy bands.

Dance of the honeybee and new physics

For more than two decades ago mathematician Barbara Shipman made rather surprising finding while working with her thesis. The 2-D projections of certain curves in flag manifold $F = SU(3)/U(1) \times U(1)$ defined by the so called momentum map look like the waggle part of the dance of the honey bee. Shipman found that one could reproduce in this framework both waggle dance and circle dance (special case of waggle dance) and the transition between these occurring as the distance of the food source from the nest reduces below some critical distance. Shipman introduced a parameter, which she called α , and found that the variation of α allows to integrate various forms of the honeybee dance to a bigger picture. Since SU(3) is the gauge group of color interactions, this unexpected finding led Shipman to as whether there might be a profound connection between quantum physics at quark level and macroscopic physics at the level of honeybee dance.

The average colleague of course regards this kind of proposal as crackpottery: the argument is that there simply cannot be any interaction between degrees of freedom in so vastly different length scales. Personally I however found this finding fascinating and wrote about the interpretation of this finding in the framework of TGD and TGD inspired consciousness. During more than two decades a lot of progress has taken place in TGD, in particular I have learned that the flag manifold F has interpretation as twistor space of CP_2 and plays a fundamental role in twistor lift of TGD. Hence it is interesting to look what this could allow to say about honeybee dance.

It turned out that one could understand the waggle parts of the honeybee dance at spacetime level in terms of the intersection of the space-time surface with the image of the Cartan subalgebra of SU(3) represented in CP_2 using exponential map. This allows to code the positional data about the food source. The frequencies assignable to the wing vibrations and waggling turn could have interpretation as cyclotron frequencies as expected if the magnetic body of the bee controls the waggle dance utilizing resonance mechanism. They could also correspond to the momenta (frequencies) defining constants of motion for geodesic in $U(1) \times U(1)$ defining one particular point of flag manifold F. Also a connection with the Chladni effect emerges: the waggle motion is along time-like curve at which Kähler force vanishes. Also the transition from waggle dance do circle dance involving also a short waggle period can be understood.

A Model for Protein Folding and Bio-catalysis

The model for the evolution of genetic code leads to the idea that the folding of proteins obeys a folding code inherited from the genetic code. The flux connections between molecules containing dark matter in macroscopic quantum phase and characterized by two integers are the basic new physics element of the model.

After some trials one ends up with a general conceptualization of the situation with the identification o magnetic flux tubes as correlates of attention at molecular level so that a direct connection with TGD inspired theory of consciousness emerges at quantitative level. This allows a far reaching generalization of the DNA as topological quantum computer paradigm and makes it much more detailed. By their asymmetric character hydrogen bonds are excellent candidates for contracted magnetic flux tubes serving as correlates of attention at molecular level.

One can consider two models. For the first model the flux tubes between amino-acids are assumed to determine the protein folding.

- 1. The constant part of free amino-acid containing O H, O =, and NH_2 would correspond to the codon XYZ in the sense that the flux tubes would carry the "color" representing the four nucleotides in terms of quark pairs. Color inheritance by flux tube reconnection makes this possible. For the amino-adics inside protein O = and N - H would correspond to YZ. Also flux tubes connecting the acceptor atoms of hydrogen bonds are required by the model of DNA as topological quantum computer. The long flux tubes between O = atoms and their length reduction in a phase transition reducing Planck constant could be essential in protein-ligand interaction.
- 2. The model predicts a code for protein folding: depending on whether also = O O = flux tubes are allowed or not, Y = Z or $Y = Z_c$ condition is satisfied by the amino-acids having N - H - O = hydrogen bond. For = O - O = bonds $Y - Y_c$ pairing holds true. If one identifies hydrogen bond with flux tube (Y(n) = Z(n + k)) the model works badly for both

options. If one assumes only that the presence of a flux tube connecting amino-acids in either direction (Y(n) = Z(n+k) or Z(n) = Y(n+k)) is a prerequisite for the formation of hydrogen bond, the model works. $Y = Z_c$ option predicts the average length of alpha bonds correctly. Y = Z rule is however favored by the study of alpha helices for four enzymes: the possible average length of alpha helix is considerably longer than the average length of alpha helix if gene is the unique gene allowing to satisfy Y = Z rule. The explicit study of alpha helices for four enzymes demonstrates that the failure to satisfy the condition for the existence of hydrogen bond fails rarely and at most for two amino-acids (for 2 amino-acids in single case only). For beta sheets there ar no failures for Y = Z option.

3. The information apparently lost in the many-to-one character of the codon-amino-acid correspondence would code for the folding of the protein and similar amino-acid sequences could give rise to different foldings. Also catalyst action would reduce to effective base pairing and one can speak about catalyst code. The DNA sequences associated with alpha helices and beta sheets are completely predictable unless one assumes a quantum counterpart of wobble base pairing meaning that N - H flux tubes are before hydrogen bonding in quantum superpositions of braid colors associated with the third nucleotides Z of codons XYZ coding for amino-acid. Only the latter option works. The outcome is very simple quantitative model for folding and catalyst action based on minimization of energy and predicting as its solutions alpha helices and beta strands.

Second model represents a diametrical opposite of the first model in the sense in that it assumes flux tube connections only between amino-acids and water molecules. These flux tubes mediate an attractive (repulsive) interaction in the case of hydrophily (hydrophoby) due to the behavior of magnetic (presumably) interaction energy as a function of Planck constant (or integers characterizing the level of dark matter) assignable to the flux tube. For hydrophoby (hydrophily) the interaction energy is minimized for long (short) flux tubes. The interaction between amino-acids is induced by this interaction in a manner analogous to how the interaction between electrons and ions induces secondary interaction between the members of a Cooper pair. The model explains the basic qualitative aspects of protein folding and the quantitative model of folding based on amino-acid-amino-acid flux tubes allows a generalization which is however discussed at numerical level.

The third proposal asks whether protein folding could be induced by the flux tube connections of protein with water's MB rather than between proteins as in the first two models. This model is certainly an idealization since S-S valence bonds are known to play an important part in the folding. These flux tube connections could be accompanied by hydrogen bonds - even longer than usual if h_{eff} as spectrum for water as has been proposed. This involves more detailed ideas about the origin of hydrophobia and hydrophilia at the level of magnetic body (MB). Hydrophilic amino acids would tend to form flux tube connections with the MB of water unlike hydrophobic amino acids. The formation of flux tube connection would serve as a correlate for attention at molecular level.

Decade after writing this chapter the vision about the role of DNA in TGD Universe evolved with inspiration coming from the model of water memory and homeopathy and the realization that homeopathy might represent a core elemement in the functioning of immune system involving new physics in an essential manner. The key idea is that dark variants of amino-acid sequences would have coded for the 2-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 antigene 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.

Getting philosophical: some comments about the problems of physics, neuroscience, and biology

In this chapter I summarize what I see as the basic philosophical problems of the recent conceptual framework of biology and neuroscience and discuss how TGD can resolve these problems. One cannot actually avoid the problems of fundamental physics and of consciousness theory so that also these are discussed to some degree. Also concrete mechanisms are discussed with aim to give an overall view about TGD inspired quantum biology.
Part I

TGD INSPIRED THEORY OF CONSCIOUSNESS

Chapter 2

Topological Geometrodynamics: Basic Visions

2.1 Introduction

Originally Topological Geometrodynamics (TGD) was proposed as a solution of the problems related to the definition of conserved four-momentum in General Relativity. It was assumed that physical space-times are representable as 4-D surfaces in certain higher-dimensional space-time having symmetries of the empty Minkowski space of Special Relativity. This is guaranteed by the decomposition $H = M^4 \times S$, where S is some compact internal space. It turned out that the choice $S = CP_2$ is unique in the sense that it predicts the symmetries of the standard model and provides a realization for Einstein's dream of geometrizing of fundamental interactions at classical level. TGD can be also regarded as a generalization of super string models obtained by replacing strings with light-like 3-surfaces or equivalently with space-like 3-surfaces: the equivalence of these identification implies quantum holography.

The construction of quantum TGD turned out to be much more than mere technical problem of deriving S-matrix from path integral formalism. A new ontology of physics (many-sheeted spacetime, zero energy ontology, generalization of the notion of number, and generalization of quantum theory based on spectrum of Planck constants giving hopes to understand what dark matter and dark energy are) and also a generalization of quantum measurement theory leading to a theory of consciousness and model for quantum biology providing new insights to the mysterious ability of living matter to circumvent the constraints posed by the second law of thermodynamics were needed. The construction of quantum TGD involves a handful of different approaches consistent with a similar overall view, and one can say that the construction of M-matrix, which generalizes the S-matrix of quantum field theories, is understood to a satisfactory degree although it is not possible to write even in principle explicit Feynman rules except at quantum field theory limit [?].

In this article I will discuss three basic visions about quantum Topological Geometrodynamics (TGD). It is somewhat matter of taste which idea one should call a vision and the selection of these three in a special role is what I feel natural just now.

- 1. The first vision is generalization of Einstein's geometrization program based on the idea that the Kähler geometry of the world of classical worlds (WCW) with physical states identified as classical spinor fields on this space would provide the ultimate formulation of physics [K133].
- 2. Second vision is number theoretical [K89] and involves three threads.
 - (a) The first thread [K125] relies on the idea that it should be possible to fuse real number based physics and physics associated with various p-adic number fields to single coherent whole by a proper generalization of number concept.
 - (b) Second thread [K126] is based on the hypothesis that classical number fields could allow to understand the fundamental symmetries of physics and and imply quantum TGD from purely number theoretical premises with associativity defining the fundamental dynamical principle both classically and quantum mechanically.

- (c) The third thread [K124] relies on the notion of infinite primes whose construction has amazing structural similarities with second quantization of super-symmetric quantum field theories. In particular, the hierarchy of infinite primes and integers allows to generalize the notion of numbers so that given real number has infinitely rich number theoretic anatomy based on the existence of infinite number of real units. This implies number theoretical Brahman=Atman identity or number theoretical holography when one consider hyper-octonionic infinite primes.
- (d) The third vision is based on TGD inspired theory of consciousness [K131], which can be regarded as an extension of quantum measurement theory to a theory of consciousness raising observer from an outsider to a key actor of quantum physics. The basic notions at quantum jump identified as as a moment of consciousness and self. Negentropy Maximization Principle (NMP) defines the fundamental variational principle and reproduces standard quantum measurement theory and predicts second law but also some totally new physics in the intersection of real and p-adic worlds where it is possible to define a hierarchy of number theoretical variants of Shannon entropy which can be also negative. In this case NMP favors the generation of entanglement and state function reduction does not mean generation of randomness anymore. This vision has obvious almost applications to biological self-organization.

My aim is to provide a bird's eye of view and my hope is that reader would take the attitude that details which cannot be explained in this kind of representation are not essential for the purpose of getting a feeling about the great dream behind TGD. I have also commented various ideas from the point of view of Quantum Mind program.

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 [L31].

2.2 Quantum Physics As Infinite-Dimensional Geometry

The first vision in its original form is a the generalization of Einstein's program for the geometrization of physics by replacing space-time with the WCW identified roughly as the space of 4-surfaces in $H = M^4 \times CP_2$. Later generalization due to replacement of H with book like structures from by real and p-adic variants of H emerged. A further book like structure of embedding space emerged via the introduction of the hierarchy of Planck constants. These generalizations do not however add anything new to the basic geometric vision.

2.2.1 Geometrization Of Fermionic Statistics In Terms Of WCW Spinor Structure

The great vision has been that the second quantization of the induced spinor fields can be understood geometrically in terms of the WCW spinor structure in the sense that the anti-commutation relations for WCW gamma matrices require anti-commutation relations for the oscillator operators for free second quantized induced spinor fields defined at space-time surface.

1. One must identify the counterparts of second quantized fermion fields as objects closely related to the configuration space spinor structure. Ramond model [B22] has as its basic field the anti-commuting field $\Gamma^k(x)$, whose Fourier components are analogous to the gamma matrices of the configuration space and which behaves like a spin 3/2 fermionic field rather than a vector field. This suggests that the are analogous to spin 3/2 fields and therefore expressible in terms of the fermionic oscillator operators so that their naturally derives from the anti-commutativity of the fermionic oscillator operators.

WCW spinor fields can have arbitrary fermion number and there are good hopes of describing the whole physics in terms of WCW spinor field. Clearly, fermionic oscillator operators would act in degrees of freedom analogous to the spin degrees of freedom of the ordinary spinor and bosonic oscillator operators would act in degrees of freedom analogous to the "orbital" degrees of freedom of the ordinary spinor field. One non-trivial implication is bosonic emergence: elementary bosons correspond to fermion anti-fermion bound states associated with the wormhole contacts (pieces of CP_2 type vacuum extremals) with throats carrying fermion and anti-fermion numbers. Fermions correspond to single throats associated with topologically condensed CP_2 type vacuum extremals.

- 2. The classical theory for the bosonic fields is an essential part of WCW geometry. It would be very nice if the classical theory for the spinor fields would be contained in the definition of the WCW spinor structure somehow. The properties of the associated with the induced spinor structure are indeed very physical. The modified massless Dirac equation for the induced spinors predicts a separate conservation of baryon and lepton numbers. The differences between quarks and leptons result from the different couplings to the CP_2 Kähler potential. In fact, these properties are shared by the solutions of massless Dirac equation of the embedding space.
- 3. Since TGD should have a close relationship to the ordinary quantum field theories it would be highly desirable that the second quantized free induced spinor field would somehow appear in the definition of the WCW geometry. This is indeed true if the complexified WCW gamma matrices are linearly related to the oscillator operators associated with the second quantized induced spinor field on the space-time surface and its boundaries. There is actually no deep reason forbidding the gamma matrices of WCW to be spin half odd-integer objects whereas in the finite-dimensional case this is not possible in general. In fact, in the finite-dimensional case the equivalence of the spinorial and vectorial vielbeins forces the spinor and vector representations of the vielbein group SO(D) to have same dimension and this is possible for D = 8-dimensional Euclidian space only. This coincidence might explain the success of 10-dimensional super string models for which the physical degrees of freedom effectively correspond to an 8-dimensional Euclidian space.
- 4. It took a long time to realize that the ordinary definition of the gamma matrix algebra in terms of the anti-commutators $\{\gamma_A, \gamma_B\} = 2g_{AB}$ must in TGD context be replaced with

$$\{\gamma_A^{\mathsf{T}}, \gamma_B\} = iJ_{AB} \ ,$$

where J_{AB} denotes the matrix elements of the Kähler form of WCW. The presence of the Hermitian conjugation is necessary because WCW gamma matrices carry fermion number. This definition is numerically equivalent with the standard one in the complex coordinates. The realization of this delicacy is necessary in order to understand how the square of the WCW Dirac operator comes out correctly.

2.2.2 Construction Of WCW Clifford Algebra In Terms Of Second Quantized Induced Spinor Fields

The construction of WCW spinor structure must have a direct relationship to quantum physics as it is usually understood. The second quantization of the space-time spinor fields is needed to define the anti-commutative gamma matrices of WCW: this means a geometrization of Fermi statistics [K144] in the sense that free fermionic quantum fields at space-time surface correspond to purely classical Clifford algebra of WCW. This is in accordance with the idea that physics at WCW level is purely classical apart from the notion of quantum jump.

The identification of the correct variational principle for the dynamics of space-time spinor fields identified as induced spinor fields has involved many trials and errors. Ironically, the final outcome was almost the most obvious guess: the so called Kähler-Dirac action. What was difficult to discover was that the well-definedness of em charge requires that the modes of K-D equation are localized at 2-D string world sheets. The same condition results also from the condition that octonionic and ordinary spinor structures are equivalent for the modes of the induced spinor field and also from the condition that quantum deformations of fermionic oscillator operator algebra requiring 2-dimensionality can be realized as realization of finite measurement resolution. Fermionic string model therefore emerges from TGD.

The notion of measurement resolution realized in terms of the inclusions of hyper-finite factors of type II_1 and having discretization using rationals or algebraic extensions of rationals

have been one of the key challenges of quantum TGD. Quantum classical correspondence suggests with measurement interaction term defined as Lagrange multiplier terms stating that classical charges belonging to Cartan algebra are equal to their quantal counterparts after state function reduction for space-time surfaces appearing in quantum superposition [K144]. This makes sense if classical charges parametrize zero modes. State function reduction would mean state function collapse in zero modes.

Kähler function equals to the real part of Kähler action coming from Euclidian space-time regions for a preferred extremal whereas Minkowski regions give an exponent of phase factor responsible for quantum interferences effects. The conjecture is that preferred extremals by internal consistency conditions are critical in the sense that they allows infinite number of vanishing second variations having interpretation as conformal deformations respecting light-likeness of the partonic orbits. Criticality is realize classically as vanishing of the super-symplectic charges for sub-algebra of the entire super-symplectic algebra. This realizes the notion of quantum criticality-one of guiding principles of quantum TGD-at space-time level.

Recently this idea has become very concrete.

- 1. There is an infinite hierarchy of quantum criticalities identified as a hierarchy of breakings of conformal symmetry in the sense that the gauge symmetry for the super-symplectic algebra having natural conformal structure is broken to a dynamical symmetry: gauge degrees of freedom are transformed to physical ones.
- 2. The sub-algebras of the supersymplectic algebra isomorphic with the algebra itself are parametrized by integer n: the conformal weights for the sub-algebra are n-multiples for those of the entire algebra. This predicts an infinite number of infinite hierarchies characterized by sequences of integers $n_{i+1} = \prod_{k \leq i} m_k$. The integer n_i characterizes the effective value of Planck constant $h_{eff} = n_i$ for a given level of hierarchy and the interpretation is in terms of dark matter. The increase of n_i takes place spontaneously since it means reduction of criticality. Both the value of n_i and the numbers of string world sheets associated with 3-surfaces at the ends of CD and connecting partonic 2-surfaces characterize measurement resolution.
- 3. The symplectic hierarchies correspond to hierarchies of inclusions for HFFs [K143] and finite measurement resolution is a property of both zero energy state and space-time surface. The original idea about addition of measurement interaction terms to the Kähler action does not seem to be needed.

Number theoretical approach in turn leads to the conclusion that space-time surfaces are either associative or co-associative in the sense that the induced gamma matrices at each point of space-time surface in their octonionic representation define a quaternionic or co-quaternionic algebra and therefore have matrix representation. The conjecture is that these identifications of space-time dynamics are consistent or even equivalent. The string sheets at which spinor modes are localized can be regarded as commutative surfaces.

The recent understanding of the Kähler-Dirac action has emerged through a painful process and has strong physical implications.

- 1. Kähler-Dirac equation at string world sheets can be solved exactly just as in string models. At the light-like boundaries the limit of K-D equation holds true and gives rise to the analog of massless Dirac equation but for K-D gamma matrices. One could have a 1-D boundary term defined by the induced Dirac equation at the light-like boundaries of string world sheet. If it is there, the modes are solutions with light-like 8-momentum which has light-like projection to space-time surface. This would give rise to a fermionic propagator in the construction of scattering amplitudes mimicking Feynman diagrammatics: note that the M^4 projection of the momentum need not be light-like.
- 2. The space-time super-symmetry generalizes to what might be called $\mathcal{N} = \infty$ supersymmetry whose least broken sub-symmetry reduces to $\mathcal{N} = 2$ broken super-symmetry generated by right-handed neutrino and ant-ineutrino [?]. The generators of the super-symmetry correspond to the oscillator operators of the induced spinor field at space-time sheet and to the super-symplectic charges. Bosonic emergence means dramatic simplifications in the formulation of quantum TGD.

3. It is also possible to generalize the twistor program to TGD framework if one accepts the use of octonionic representation of the gamma matrices of embedding space and hyperquaternionicity of space-time surfaces [K132]: what one obtains is 8-D generalization of the twistor Grassmann approach allowing non-light-like M^4 momenta. Essential condition is that octonionic and ordinary spinor structures are equivalent at string world sheets.

2.2.3 ZEO And WCW Geometry

In the ZEO quantum states have vanishing net values of conserved quantum numbers and decompose to superposition of pairs of positive and negative energy states defining counterparts of initial and final states of a physical event in standard ontology.

ZEO

ZEO was forced by the interpretational problems created by the vacuum extremal property of Robertson-Walker cosmologies imbedded as 4-surfaces in $M^4 \times CP_2$ meaning that the density of inertial mass (but not gravitational mass) for these cosmologies was vanishing meaning a conflict with Equivalence Principle. The most feasible resolution of the conflict comes from the realization that GRT space-time is obtained by lumping the sheets of many-sheeted space-time to M^4 endowed with effective metric. Vacuum extremals could however serve as models for GRT space-times such that the effective metric is identified with the induced metric [K137]. This is true if space-time is genuinely single-sheeted. In the models of astrophysical objects and cosmology vacuum extremals have been used [K119].

In zero energy ontology physical states are replaced by pairs of positive and negative energy states assigned to the past *resp.* future boundaries of causal diamonds defined as pairs of future and past directed light-cones ($\delta M_{\pm}^4 \times CP_2$). The net values of all conserved quantum numbers of zero energy states vanish. Zero energy states are interpreted as pairs of initial and final states of a physical event such as particle scattering so that only events appear in the new ontology. It is possible to speak about the energy of the system if one identifies it as the average positive energy for the positive energy part of the system. Same applies to other quantum numbers.

The matrix ("M-matrix") representing time-like entanglement coefficients between positive and negative energy states unifies the notions of S-matrix and density matrix since it can be regarded as a complex square root of density matrix expressible as a product of real squared of density matrix and unitary S-matrix. The system can be also in thermal equilibrium so that thermodynamics becomes a genuine part of quantum theory and thermodynamical ensembles cease to be practical fictions of the theorist. In this case M-matrix represents a superposition of zero energy states for which positive energy state has thermal density matrix.

ZEO combined with the notion of quantum jump resolves several problems. For instance, the troublesome questions about the initial state of universe and about the values of conserved quantum numbers of the Universe can be avoided since everything is in principle creatable from vacuum. Communication with the geometric past using negative energy signals and time-like entanglement are crucial for the TGD inspired quantum model of memory and both make sense in zero energy ontology. ZEO leads to a precise mathematical characterization of the finite resolution of both quantum measurement and sensory and cognitive representations in terms of inclusions of von Neumann algebras known as hyperfinite factors of type II_1 . The space-time correlate for the finite resolution is discretization which appears also in the formulation of quantum TGD.

Causal diamonds

The embedding space correlates for ZEO are causal diamonds (CDs) CD serves as the correlate zero energy state at embedding space-level whereas space-time sheets having their ends at the light-like boundaries of CD are the correlates of the system at the level of 4-D space-time. Zero energy state can be regarded as a quantum superposition of space-time sheets with fermionic and other quantum numbers assignable to the partonic 2-surfaces at the ends of the space-time sheets.

1. The basic construct in the ZEO 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 ZEO 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. Also unions of CDs are possible.
- 3. Without any restrictions CDs would be parametrized by the position of say lower tip of CD and by the relative M^4 coordinates of the upper tip with respect to the lower one so that the moduli space would be $M^4 \times M_+^4$. p-Adic length scale hypothesis follows if the values of temporal distance T between tips of CD come in powers of 2^n : $T = 2^n T_0$. This would reduce the future light-cone M_+^4 reduces to a union of hyperboloids with quantized value of light-cone proper time. A possible interpretation of this distance is as a quantized cosmic time. Also the quantization of the hyperboloids to a lattices of discrete points classified by discrete sub-groups of Lorentz group is an attractive proposal and the quantization of cosmic redshifts provides some support for it.

ZEO forces to replaced the original WCW by a union of WCWs associated with CDs and their unions. This does not however mean any problems of principle since Clifford algebras are simply tensor products of the Clifford algebras of CDs for the unions of CDs.

Generalization of S-matrix in ZEO

ZEO forces the generalization of S-matrix with a triplet formed by U-matrix, M-matrix, and Smatrix. The basic vision is that quantum theory is at mathematical level a complex square root of thermodynamics. What happens in quantum jump was already discussed.

- 1. M-matrices are matrices between positive and negative energy parts of the zero energy state and correspond to the ordinary S-matrix. M-matrix is a product of a hermitian square root call it H - of density matrix ρ and universal S-matrix S. There is infinite number of different Hermitian square roots H_i of density matrices assumed to define orthogonal matrices with respect to the inner product defined by the trace: $Tr(H_iH_j) = 0$. One can interpret square roots of the density matrices as a Lie algebra acting as symmetries of the S-matrix. The most natural identification is in terms of super-symplectic algebra or as its sub-algebra. Since these operators should not change the vanishing quantum number of zero energy states, a natural identification would be as bilinears of the generators of super-symplectic generators associated with the opposite boundaries of CD and having vanishing net quantum numbers.
- 2. One can consider a generalization of M-matrices so that they would be analogous to the elements of Kac-Moody algebra. These M-matrices would involve all powers of S.
 - (a) The orthogonality with respect to the inner product defined by $\langle A|B \rangle = Tr(AB)$ requires the conditions $Tr(H_1H_2S^n) = 0$ for $n \neq 0$ and H_i are Hermitian matrices appearing as square root of density matrix. H_1H_2 is hermitian if the commutator $[H_1, H_2]$ vanishes. It would be natural to assign *n*:th power of *S* to the CD for which the scale is *n* times the CP_2 scale.
 - (b) Trace possibly quantum trace for hyper-finite factors of type II_1) is the analog of integration and the formula would be a non-commutative analog of the identity $\int_{S^1} exp(in\phi)d\phi = 0$ and pose an additional condition to the algebra of M-matrices.
 - (c) It might be that one must restrict M matrices to a Cartan algebra and also this choice would be a process analogous to state function reduction. Since density matrix becomes an observable in TGD Universe, this choice could be seen as a direct counterpart for the choice of a maximal number of commuting observables which would be now hermitian square roots of density matrices. Therefore ZEO gives good hopes of reducing basic quantum measurement theory to infinite-dimensional Lie-algebra.

The collections of M-matrices defined as time reversals of each other define the sought for two natural state basis. 1. As for ordinary S-matrix, one can construct the states in such a way that either positive or negative energy part of the state has well defined particle numbers, spin, etc... resulting in state function preparation. Therefore one has two kinds of M-matrices: M_K^{\pm} and for both of these the above orthogonality relations hold true. This implies also two kinds of U-matrices call them U^{\pm} . The natural assumption is that the two M-matrices differ only by Hermitian conjugation so that one would have $M_K^- = (M_K^+)^{\dagger}$.

One can assign opposite arrows of geometric time to these states and the proposal is that the arrow of time is a result of a process analogous to spontaneous magnetization. The possibility that the arrow of geometric time could change in quantum jump has been already discussed.

2. Unitary U-matrix U^{\pm} is induced from a projector to the zero energy state basis $|K^{\pm}\rangle$ acting on the state basis $|K^{\mp}\rangle$ and the matrix elements of U-matrix are obtained by acting with the representation of identity matrix in the space of zero energy states as $I = \sum_{K} |K^{+}\rangle \langle K^{+}|$ on the zero energy state $|K^{-}\rangle$ (the action on K^{+} is trivial!) and gives

$$U_{KL}^{+} = Tr(M_{K}^{+}M_{L}^{+})$$
.

Note that finite measurement resolution requires that the trace operation is q-trace rather than ordinary trace.

- 3. As the detailed discussion of the anatomy of quantum jump demonstrated, the first step in state function reduction is the choice of M_K^{\pm} meaning the choice of the hermitian square root of a density matrix. A quantal selection of the measured observable takes place. This step is followed by a choice of "initial" state analogous to state function preparation and a choice of the "final state" analogous to state function reduction. The net outcome is the transition $|K^{\pm}\rangle \rightarrow |L^{\pm}\rangle$. It could also happen that instead of state function reduction as third step unitary process U^{\mp} (note the change of the sign factor!) takes place and induces the change of the arrow of geometric time.
- 4. As noticed, one can imagine even higher level choices and this would correspond to the choice of the commuting set of hermitian matrices H defining the allowed square roots of density matrices as a set of mutually commuting observables.
- 5. The original naïve belief that the unitary U-matrix has as its rows orthonormal M-matrices turned out to be wrong. One can deduce the general structure of U-matrix from first principles by identifying it as a time evolution operator in the space of moduli of causal diamonds relating to each other M-matrices. Inner product for M-matrices gives the matrix elements of U-matrix. S-matrix can be identified as a representation for the exponential of the Virasoro generator L_{-1} for the super-symplectic algebra. The detailed construction of U-matrix in terms of M-matrices and S-matrices depending on CD moduli is discussed in [K85].

2.2.4 Quantum Criticality, Strong Form Form of Holography, and WCW Geometry

Quantum TGD and WCW geometry in particular can be understood in terms of two principles: Quantum Criticality (QC) and Strong form of Holography (SH).

Quantum Criticality

In its original form QC stated that the Kähler couplings strength appearing in the exponent of vacuum functional identifiable uniquely as the exponent of Kähler function defining the Kähler metric of WCW defines the analog of partition function of a thermodynamical system. Later it became clear that Kähler action in Minkowskian space-time regions is imaginary (by \sqrt{g} factor) so that the exponent become that of complex number. The interpretation in ZEO is in terms of quantum TGD as "square root of thermodynamics" vision. Minkowskian Kähler action is the analog of action of quantum field theories.

TGD should be unique. The analogy with thermodynamics implies that Kähler coupling strength α_K is analogous to temperature. The natural guess is that it corresponds to a critical

temperature at which a phase transition between two phases occurs. It is of course possible that there are several critical values of α_K .

QC is physically very attractive since it would give maximally complex Universe. At quantum criticality long range fluctuations would be present and make possible macroscopic quantum coherence especially relevant for life.

In 2-D critical systems conformal symmetry provides the mathematical description of criticality and in TGD something similar but based on a huge generalization of the conformal symmetries is expected. Ordinary conformal symmetries are indeed replaced by super-symplectic isometries, by the generalized conformal symmetries acting on light-cone boundary and on light-like orbits of partonic 2-surfaces, and by the ordinary conformal symmetries at partonic 2-surfaces and string world sheets carrying spinors. Even a quaternionic generalization of conformal symmetries must be considered.

Strong Form of Holography

Strong form of holography (SH) is the second big principle. It is strongly suggested by the strong form of general coordinate invariance (SGCI) stating that the fundamental objects can be taken to be either the light-like orbits of partonic 2-surfaces or space-like 3-surfaces at the ends of causal diamonds (CDs). This would imply that partonic 2-surfaces at their intersection at the boundaries of CDs carry the data about quantum states.

As a matter fact, one must include also string world sheets at which fermions are localized - this for instance by the condition that em charge is well-defined. String world sheets carry vanishing induced W boson fields (they would mix different charge states) and the Kähler-Dirac gamma matrices are parallel to them. These conditions give powerful integrability conditions and it remains to be seen whether solutions to them indeed exist.

The best manner to proceed is to construct preferred extremals using SH - that is by assuming just string world sheets and partonic 2-surfaces intersecting by discrete point set as given, and finding the preferred extremals of Kähler action containing them and satisfying the boundary conditions at string world sheets and partonic 2-surfaces.

If this construction works, it must involve boundary conditions fixing the space-time surfaces to very high degree. Due to the non-determinism of Kähler action implied by its huge vacuum degeneracies, one however expects a gauge degeneracy. QC indeed suggests non-determinism. By 2-D analogy one expects the analogs of conformal symmetries acting as gauge symmetries. The proposal is that the fractal hierarchy of mutually isomorphic sub-algebras of super-symplectic algebra (and possibly of all conformal algebras involved) having conformal weights, which are *n*ples of those for the entire algebra act as gauge symmetries so that the Noether charges for this sub-algebra would vanish. This would be the case at the ends of preferred extremals at both boundaries of CDs. This almost eliminates the classical degrees of freedom outside string world sheets and partonic 2-surfaces, and thus realizes the strong form of holography. In the fermionic sector the fermionic super-symplectic charges in the sub-algebra annihilate the physical states: this is a generalization of Super-Virasoro and Super Kac-Moody conditions.

In the phase transitions increasing the value of n the sub-algebra of gauge symmetries is reduced and gauge degrees of freedom become physical ones. By QC this transition occurs spontaneously. TGD Universe is like ball at the top of hill at the top of: ad infinitum and its evolution is endless dropping down. In TGD inspired theory of consciousness, one can understand living systems as systems fighting to stay at given level of criticality.

One could say that the conformal subalgebra is analogous to that defined by functions of $w = z^n$ act as conformal symmetries. One can also see the space-time surfaces at the level n as analogous to Riemann surface for function $f(z) = z^{1/n}$ conformal gauge symmetries as those defined by functions of z. This brings in n sheets not connected by conformal gauge symmetries. Hence the conformal equivalence classes of sheets give rise n-fold physical degeneracy. An effective description for this would be in terms of n-fold singular covering of the embedding space introduced originally but this is only an auxiliary concept.

A natural interpretation of the hierarchy of conformal criticalities is as a hierarchy of Planck constants $h_{eff} = n \times h$. The identification is suggested by the interpretation of n as the number of sheets in the singular covering of the space-time surface for which the sheets at the ends of The hierarchy of Planck constants allows to consider several interpretations.

- 1. If one regards the sheets of the covering as distinct, one has single critical value of g_K^2 and of h. This is the fundamental interpretation and justifies the subscript " $_{eff}$ " in $h_{eff} = n \times h$.
- 2. If the sheets of the covering are are lumped to a single sheet (this is done for all sheets of the many-sheeted space-time in General Relativity approximation), there are two possible interpretations. There is single critical value of g_K^2 and a hierarchy of Planck constants $h_{eff} = n \times h$ giving rise to $\alpha_K(n) = g_K^2/2h_{eff}$. Alternatively, there is single value of Planck constant and a hierarchy of critical values $\alpha_K(n) = (g_K^2/2h)/n$ having an accumulation point at origin (zero temperature).

Non-commutative embedding space and strong form of holography

The precise formulation of strong form of holography (SH) is one of the technical problems in TGD. A comment in FB page of Gareth Lee Meredith led to the observation that besides the purely number theoretical formulation based on commutativity also a symplectic formulation in the spirit of non-commutativity of embedding space coordinates can be considered. One can however use only the notion of Lagrangian manifold and avoids making coordinates operators leading to a loss of General Coordinate Invariance (GCI).

Quantum group theorists have studied the idea that space-time coordinates are non-commutative and tried to construct quantum field theories with non-commutative space-time coordinates (see http://tinyurl.com/z3m8sny). My impression is that this approach has not been very successful. In Minkowski space one introduces antisymmetry tensor J_{kl} and uncertainty relation in linear M^4 coordinates m^k would look something like $[m^k, m^l] = l_P^2 J^{kl}$, where l_P is Planck length. This would be a direct generalization of non-commutativity for momenta and coordinates expressed in terms of symplectic form J^{kl} .

1+1-D case serves as a simple example. The non-commutativity of p and q forces to use either p or q. Non-commutativity condition reads as $[p,q] = \hbar J^{pq}$ and is quantum counterpart for classical Poisson bracket. Non-commutativity forces the restriction of the wave function to be a function of p or of q but not both. More geometrically: one selects Lagrangian sub-manifold to which the projection of J_{pq} vanishes: coordinates become commutative in this sub-manifold. This condition can be formulated purely classically: wave function is defined in Lagrangian submanifolds to which the projection of J vanishes. Lagrangian manifolds are however not unique and this leads to problems in this kind of quantization. In TGD framework the notion of "World of Classical Worlds" (WCW) allows to circumvent this kind of problems and one can say that quantum theory is purely classical field theory for WCW spinor fields. "Quantization without quantization" would have Wheeler stated it.

GCI poses however a problem if one wants to generalize quantum group approach from M^4 to general space-time: linear M^4 coordinates assignable to Lie-algebra of translations as isometries do not generalize. In TGD space-time is surface in embedding space $H = M^4 \times CP_2$: this changes the situation since one can use 4 embedding space coordinates (preferred by isometries of H) also as space-time coordinates. The analog of symplectic structure J for M^4 makes sense and number theoretic vision involving octonions and quaternions leads to its introduction. Note that CP_2 has naturally symplectic form.

Could it be that the coordinates for space-time surface are in some sense analogous to symplectic coordinates (p_1, p_2, q_1, q_2) so that one must use either (p_1, p_2) or (q_1, q_2) providing coordinates for a Lagrangian sub-manifold. This would mean selecting a Lagrangian sub-manifold of space-time surface? Could one require that the sum $J_{\mu\nu}(M^4) + J_{\mu\nu}(CP_2)$ for the projections of symplectic forms vanishes and forces in the generic case localization to string world sheets and partonic 2-surfaces. In special case also higher-D surfaces - even 4-D surfaces as products of Lagrangian 2-manifolds for M^4 and CP_2 are possible: they would correspond to homologically trivial cosmic strings $X^2 \times Y^2 \subset M^4 \times CP_2$, which are not anymore vacuum extremals but minimal surfaces if the action contains besides Käction also volume term.

But why this kind of restriction? In TGD one has strong form of holography (SH): 2-D string world sheets and partonic 2-surfaces code for data determining classical and quantum evolution.

Could this projection of $M^4 \times CP_2$ symplectic structure to space-time surface allow an elegant mathematical realization of SH and bring in the Planck length l_P defining the radius of twistor sphere associated with the twistor space of M^4 in twistor lift of TGD? Note that this can be done without introducing embedding space coordinates as operators so that one avoids the problems with general coordinate invariance. Note also that the non-uniqueness would not be a problem as in quantization since it would correspond to the dynamics of 2-D surfaces.

The analog of brane hierarchy for the localization of spinors - space-time surfaces; string world sheets and partonic 2-surfaces; boundaries of string world sheets - is suggestive. Could this hierarchy correspond to a hierarchy of Lagrangian sub-manifolds of space-time in the sense that $J(M^4) + J(CP_2) = 0$ is true at them? Boundaries of string world sheets would be trivially Lagrangian manifolds. String world sheets allowing spinor modes should have $J(M^4) + J(CP_2) = 0$ at them. The vanishing of induced W boson fields is needed to guarantee well-defined em charge at string world sheets and that also this condition allow also 4-D solutions besides 2-D generic solutions.

This condition is physically obvious but mathematically not well-understood: could the condition $J(M^4) + J(CP_2) = 0$ force the vanishing of induced W boson fields? Lagrangian cosmic string type minimal surfaces $X^2 \times Y^2$ would allow 4-D spinor modes. If the light-like 3-surface defining boundary between Minkowskian and Euclidian space-time regions is Lagrangian surface, the total induced Kähler form Chern-Simons term would vanish. The 4-D canonical momentum currents would however have non-vanishing normal component at these surfaces. I have considered the possibility that TGD counterparts of space-time super-symmetries could be interpreted as addition of higher-D right-handed neutrino modes to the 1-fermion states assigned with the boundaries of string world sheets [K115].

Induced spinor fields at string world sheets could obey the "dynamics of avoidance" in the sense that *both* the induced weak gauge fields W, Z^0 and induced Kähler form (to achieve this U(1) gauge potential must be sum of M^4 and CP_2 parts) would vanish for the regions carrying induced spinor fields. They would couple only to the *induced em field* (!) given by the R_{12} part of CP_2 spinor curvature [L2] for D = 2, 4. For D = 1 at boundaries of string world sheets the coupling to gauge potentials would be non-trivial since gauge potentials need *not* vanish there. Spinorial dynamics would be extremely simple and would conform with the vision about symmetry breaking of weak group to electromagnetic gauge group.

An alternative - but of course not necessarily equivalent - attempt to formulate SH would be in terms of number theoretic vision. Space-time surfaces would be associative or co-associative depending on whether tangent space or normal space in embedding space is associative - that is quaternionic. These two conditions would reduce space-time dynamics to associativity and commutativity conditions. String world sheets and partonic 2-surfaces would correspond to maximal commutative or co-commutative sub-manifolds of embedding space. Commutativity (cocommutativity) would mean that tangent space (normal space as a sub-manifold of space-time surface) has complex tangent space at each point and that these tangent spaces integrate to 2surface. SH would mean that data at these 2-surfaces would be enough to construct quantum states. String world sheet boundaries would in turn correspond to real curves of the complex 2-surfaces intersecting partonic 2-surfaces at points so that the hierarchy of classical number fields would have nice realization at the level of the classical dynamics of quantum TGD. The analogy with branes and super-symmetry force to consider two options.

Two options for fundamental variational principle

One ends up to two options for the fundamental variational principle.

Option I: The *fundamental* action principle for space-time surfaces contains besides 4-D action also 2-D action assignable to string world sheets, whose topological part (magnetic flux) gives rise to a coupling term to Kähler gauge potentials assignable to the 1-D boundaries of string world sheets containing also geodesic length part. Super-symplectic symmetry demands that modified Dirac action has 1-, 2-, and 4-D parts: spinor modes would exist at both string boundaries, string world sheets, and space-time interior. A possible interpretation for the interior modes would be as generators of space-time super-symmetries [K115].

This option is not quite in the spirit of SH and string tension appears as an additional parameter. Also the conservation of em charge forces 2-D string world sheets carrying vanishing induced W fields and this is in conflict with the existence of 4-D spinor modes unless they satisfy the same condition. This looks strange.

Option II: Stringy action and its fermionic counterpart are effective actions only and justified by SH. In this case there are no problems of interpretation. SH requires only that the induced spinor fields at string world sheets determine them in the interior much like the values of analytic function at curve determine it in an open set of complex plane. At the level of quantum theory the scattering amplitudes should be determined by the data at string world sheets. If the induced W fields at string world sheets are vanishing, the mixing of different charge states in the interior of X^4 would not make itself visible at the level of scattering amplitudes!

If string world sheets are generalized Lagrangian sub-manifolds, only the induced em field would be non-vanishing and electroweak symmetry breaking would be a fundamental prediction. This however requires that M^4 has the analog of symplectic structure suggested also by twistorialization. This in turn provides a possible explanation of CP breaking and matter-antimatter asymmetry. In this case 4-D spinor modes do not define space-time super-symmetries.

The latter option conforms with SH and would mean that the theory is amazingly simple. String world sheets together with number theoretical space-time discretization meaning small breaking of SH would provide the basic data determining classical and quantum dynamics. The Galois group of the extension of rationals defining the number-theoretic space-time discretization would act as a covering group of the covering defined by the discretization of the space-time surface, and the value of $h_{eff}/h = n$ would correspond to the dimension of the extension dividing the order of its Galois group. The phase transitions reducing n would correspond to spontaneous symmetry breaking leading from Galois group to a subgroup and the transition would replace n with its factor.

The ramified primes of the extension would be preferred primes of given extension. The extensions for which the number of p-adic space-time surfaces representable also as a real algebraic continuation of string world sheets to preferred extrenal is especially large would be physically favored as also corresponding ramified primes. In other words, maximal number of p-adic imaginations would be realizable so that these extensions and corresponding ramified primes would be winners in the number-theoretic fight for survival. Whether this conforms with p-adic length scale hypothesis, remains an open question.

Consequences

The outcome is a precise identification of preferred extremals and therefore also a precise definition of Kähler function as Kähler action in Euclidian space-time regions: the Kähler action in Minkowskian regions takes the role of action in quantum field theories and emerges because one has complex square root of thermodynamics. The outcome is a vision combining several big ideas thought earlier to be independent.

- 1. Effective 2-dimensionality, which was already 30 years ago realized to be unavoidable but meant a catastrophe with the physical understanding that I had at that time. Now it is the outcome of SH implied by SGCI.
- 2. QC is very naturally realized in terms of generalized conformal symmetries and implies a fractal hierarchy of quantum criticalities, and gives as a side product the hierarchy of Planck constants, which emerged originally from purely physical considerations rather than from TGD. Also the hierarchy of inclusions of hyper-finite factors is a natural outcome as well as the interpretation in terms of measurement resolutions (increasing when *n* increases by integer factor).
- 3. The reduction of quantum TGD proper by SH so that only data at partonic 2-surfaces and string world sheets are used to construct the scattering amplitudes. This allows to realized number theoretical universality both at the level of space-time and WCW using algebraic continuation of the physics from an algebraic extension of rationals to real and p-adic number fields. This adelic picture together with Negentropy Maximization Principle (NMP) allows to understand the preferred p-adic primes and deduce a generalization of p-adic length scale hypothesis.

2.2.5 Hyper-Finite Factors And The Notion Of Measurement Resolution

The work with TGD inspired model [K7, K6] for topological quantum computation [B16] led to the realization that von Neumann algebras [A30], in particular so called hyper-finite factors of type II_1 [A22], seem to provide the mathematics needed to develop a more explicit view about the construction of S-matrix. Later came the realization that the Clifford algebra of WCW defines a canonical representation of hyper-finite factors of type II₁ and that WCW spinor fields give rise to HFFs of type III₁ encountered also in relativistically invariant quantum field theories [K143].

Philosophical ideas behind von Neumann algebras

The goal of von Neumann was to generalize the algebra of quantum mechanical observables. The basic ideas behind the von Neumann algebra are dictated by physics. The algebra elements allow Hermitian conjugation * and observables correspond to Hermitian operators. Any measurable function f(A) of operator A belongs to the algebra and one can say that non-commutative measure theory is in question.

The predictions of quantum theory are expressible in terms of traces of observables. Density matrix defining expectations of observables in ensemble is the basic example. The highly non-trivial requirement of von Neumann was that identical a priori probabilities for a detection of states of infinite state system must make sense. Since quantum mechanical expectation values are expressible in terms of operator traces, this requires that unit operator has unit trace: tr(Id) = 1.

In the finite-dimensional case it is easy to build observables out of minimal projections to 1-dimensional eigen spaces of observables. For infinite-dimensional case the probably of projection to 1-dimensional sub-space vanishes if each state is equally probable. The notion of observable must thus be modified by excluding 1-dimensional minimal projections, and allow only projections for which the trace would be infinite using the straightforward generalization of the matrix algebra trace as the dimension of the projection.

The non-trivial implication of the fact that traces of projections are never larger than one is that the eigen spaces of the density matrix must be infinite-dimensional for non-vanishing projection probabilities. Quantum measurements can lead with a finite probability only to mixed states with a density matrix which is projection operator to infinite-dimensional subspace. The simple von Neumann algebras for which unit operator has unit trace are known as factors of type II_1 [A22].

The definitions of adopted by von Neumann allow however more general algebras. Type I_n algebras correspond to finite-dimensional matrix algebras with finite traces whereas I_{∞} associated with a separable infinite-dimensional Hilbert space does not allow bounded traces. For algebras of type *III* non-trivial traces are always infinite and the notion of trace becomes useless being replaced by the notion of state which is generalization of the notion of thermodynamical state. The fascinating feature of this notion of state is that it defines a unique modular automorphism of the factor defined apart from unitary inner automorphism and the question is whether this notion or its generalization might be relevant for the construction of M-matrix in TGD.

Von Neumann, Dirac, and Feynman

The association of algebras of type I with the standard quantum mechanics allowed to unify matrix mechanism with wave mechanics. Note however that the assumption about continuous momentum state basis is in conflict with separability but the particle-in-box idealization allows to circumvent this problem (the notion of space-time sheet brings the box in physics as something completely real).

Because of the finiteness of traces von Neumann regarded the factors of type II_1 as fundamental and factors of type III as pathological. The highly pragmatic and successful approach of Dirac [K144] based on the notion of delta function, plus the emergence of generalized Feynman graphs [K57], the possibility to formulate the notion of delta function rigorously in terms of distributions [A33, A23], and the emergence of path integral approach [A39] meant that von Neumann approach was forgotten by particle physicists.

Algebras of type II_1 have emerged only much later in conformal and topological quantum field theories [A18, A41] allowing to deduce invariants of knots, links and 3-manifolds. Also al-

gebraic structures known as bi-algebras, Hopf algebras, and ribbon algebras [A14, A42] relate closely to type II_1 factors. In topological quantum computation [B16] based on braid groups [A45] modular S-matrices they play an especially important role.

In algebraic quantum field theory [A25] defined in Minkowski space the algebras of observables associated with bounded space-time regions correspond quite generally to the type III_1 hyper-finite factor [A6, A28].

Hyper-finite factors in quantum TGD

The following argument suggests that von Neumann algebras known as hyper-finite factors (HFFs) of type II₁ and III₁- the latter appearing in relativistic quantum field theories provide also the proper mathematical framework for quantum TGD.

- 1. The Clifford algebra of the infinite-dimensional Hilbert space is a von Neumann algebra known as HFF of type II₁. There also the Clifford algebra at a given point (light-like 3-surface) of WCW is therefore HFF of type II₁. If the fermionic Fock algebra defined by the fermionic oscillator operators assignable to the induced spinor fields (this is actually not obvious!) is infinite-dimensional it defines a representation for HFF of type II₁. Super-conformal symmetry suggests that the extension of the Clifford algebra defining the fermionic part of a super-conformal algebra by adding bosonic super-generators representing symmetries of WCW respects the HFF property. It could however occur that HFF of type II_{∞} results.
- 2. WCW is a union of sub-WCWs associated with causal diamonds (CD) defined as intersections of future and past directed light-cones. One can allow also unions of CDs and the proposal is that CDs within CDs are possible. Whether CDs can intersect is not clear.
- 3. The assumption that the M^4 proper distance *a* between the tips of CD is quantized in powers of 2 reproduces p-adic length scale hypothesis but one must also consider the possibility that *a* can have all possible values. Since SO(3) is the isotropy group of CD, the CDs associated with a given value of *a* and with fixed lower tip are parameterized by the Lobatchevski space L(a) = SO(3, 1)/SO(3). Therefore the CDs with a free position of lower tip are parameterized by $M^4 \times L(a)$. A possible interpretation is in terms of quantum cosmology with *a* identified as cosmic time [K119]. Since Lorentz boosts define a non-compact group, the generalization of so called crossed product construction strongly suggests that the local Clifford algebra of WCW is HFF of type III₁. If one allows all values of *a*, one ends up with $M^4 \times M_+^4$ as the space of moduli for WCW.

Hyper-finite factors and M-matrix

HFFs of type III₁ provide a general vision about M-matrix [K143].

- 1. The factors of type III allow unique modular automorphism Δ^{it} (fixed apart from unitary inner automorphism). This raises the question whether the modular automorphism could be used to define the M-matrix of quantum TGD. This is not the case as is obvious already from the fact that unitary time evolution is not a sensible concept in ZEO.
- 2. Concerning the identification of M-matrix the notion of state as it is used in theory of factors is a more appropriate starting point than the notion modular automorphism but as a generalization of thermodynamical state is certainly not enough for the purposes of quantum TGD and quantum field theories (algebraic quantum field theorists might disagree!). ZEO requires that the notion of thermodynamical state should be replaced with its "complex square root" abstracting the idea about M-matrix as a product of positive square root of a diagonal density matrix and a unitary S-matrix. This generalization of thermodynamical state -if it exists- would provide a firm mathematical basis for the notion of M-matrix and for the fuzzy notion of path integral.
- 3. The existence of the modular automorphisms relies on Tomita-Takesaki theorem [A37], which assumes that the Hilbert space in which HFF acts allows cyclic and separable vector serving as ground state for both HFF and its commutant. The translation to the language of physicists

states that the vacuum is a tensor product of two vacua annihilated by annihilation oscillator type algebra elements of HFF and creation operator type algebra elements of its commutant isomorphic to it. Note however that these algebras commute so that the two algebras are not hermitian conjugates of each other. This kind of situation is exactly what emerges in ZEO: the two vacua can be assigned with the positive and negative energy parts of the zero energy states entangled by M-matrix.

4. There exists infinite number of thermodynamical states related by modular automorphisms. This must be true also for their possibly existing "complex square roots". Physically they would correspond to different measurement interactions giving rise to Kähler functions of WCW differing only by a real part of holomorphic function of complex coordinates of WCW and arbitrary function of zero mode coordinates and giving rise to the same Kähler metric of WCW.

The concrete construction of M-matrix utilizing the idea of bosonic emergence (bosons as fermion anti-fermion pairs at opposite throats of wormhole contact) meaning that bosonic propagators reduce to fermionic loops identifiable as wormhole contacts leads to generalized Feynman rules for M-matrix in which Kähler-Dirac action containing measurement interaction term defines stringy propagators [K37]. This *M*-matrix should be consistent with the above proposal.

Connes tensor product as a realization of finite measurement resolution

The inclusions $\mathcal{N} \subset \mathcal{M}$ of factors allow an attractive mathematical description of finite measurement resolution in terms of Connes tensor product [A16] but do not fix M-matrix as was the original optimistic belief.

- 1. In ZEO \mathcal{N} would create states experimentally indistinguishable from the original one. Therefore \mathcal{N} takes the role of complex numbers in non-commutative quantum theory. The space \mathcal{M}/\mathcal{N} would correspond to the operators creating physical states modulo measurement resolution and has typically fractal dimension given as the index of the inclusion. The corresponding spinor spaces have an identification as quantum spaces with non-commutative \mathcal{N} -valued coordinates.
- 2. This leads to an elegant description of finite measurement resolution. Suppose that a universal M-matrix describing the situation for an ideal measurement resolution exists as the idea about square root of state encourages to think. Finite measurement resolution forces to replace the probabilities defined by the M-matrix with their \mathcal{N} averaged counterparts. The "averaging" would be in terms of the complex square root of \mathcal{N} -state and a direct analog of functionally or path integral over the degrees of freedom below measurement resolution defined by (say) length scale cutoff.
- 3. One can construct also directly M-matrices satisfying the measurement resolution constraint. The condition that \mathcal{N} acts like complex numbers on M-matrix elements as far as \mathcal{N} averaged probabilities are considered is satisfied if M-matrix is a tensor product of M-matrix in $\mathcal{M}(\mathcal{N})$ interpreted as finite-dimensional space with a projection operator to \mathcal{N} . The condition that \mathcal{N} averaging in terms of a complex square root of \mathcal{N} state produces this kind of M-matrix poses a very strong constraint on M-matrix if it is assumed to be universal (apart from variants corresponding to different measurement interactions).

Number theoretical braids as space-time correlates for finite measurement resolution

Finite measurement resolution has discretization as a space-time counterpart. In the intersection of real and p-adic worlds defines as partonic 2-surfaces with a mathematical representation allowing interpretation in terms of real or p-adic number fields one can identify points common to real and p-adic worlds as rational points and common algebraic points (in preferred coordinates dictated by symmetries of embedding space). Quite generally, one can identify rational points and algebraic points in some extension of rationals as points defining the initial points of what might be called number theoretical braid beginning from the partonic 2-surface at the past boundary of CD and

connecting it with the future boundary of CD. The detailed definition of the braid inside lightlike 3-surface is not relevant if only the information at partonic 2-surface is relevant for quantum physics.

Number theoretical braids are especially relevant for topological QFT aspect of quantum TGD. The topological QFT associated with braids accompanying light-like 3-surfaces having interpretation as lines of generalized Feynman diagrams should be important part of the definition of amplitudes assigned to generalized Feynman diagrams. The number theoretic braids relate also closely to a symplectic variant of conformal field theory emerges very naturally in TGD framework (symplectic symmetries acting on $\delta M_{\pm}^4 \times CP_2$ are in question) and this leads to a concrete proposal for how to construct n-point functions needed to calculate M-matrix [K37]. The mechanism guaranteeing the predicted absence of divergences in M-matrix elements can be understood in terms of vanishing of symplectic invariants as two arguments of n-point function coincide.

Quantum spinors and fuzzy quantum mechanics

The notion of quantum spinor leads to a quantum mechanical description of fuzzy probabilities [K143]. For quantum spinors state function reduction to spin eigenstates cannot be performed unless quantum deformation parameter $q = exp(i2\pi/n)$ equals to q = 1. The reason is that the components of quantum spinor do not commute: it is however possible to measure the commuting operators representing moduli squared of the components giving the probabilities associated with "true" and "false". Therefore the probability for either spin state becomes a quantized observable. The universal eigenvalue spectrum for probabilities does not in general contain (1,0) so that quantum qbits are inherently fuzzy. State function reduction would occur only after a transition to q=1 phase and de-coherence is not a problem as long as it does not induce this transition.

Concrete realization of finite measurement resolution

The recent view about the realization of finite measurement resolution is surprisingly concrete.

1. The hierarchy of Planck constants $h_{eff} = n \times h$ relates to a hierarchy of criticalities and hierarchy of measurement resolutions since each breaking of symplectic conformal symmetries transforms some gauge degrees of freedom to physical ones making possible improved resolution. For the conformal symmetries associated with the spinor modes the identification as unbroken gauge symmetries is the natural one and conforms with the interpretation as counterparts of gauge symmetries. The hierarchies of conformal symmetry breakings can be identified as hierarchies of inclusions of HFFs. Criticality would generate dark matter phase characterized by n.

The conformal sub-algebra realized as gauge transformations corresponds to the included algebra gets smaller as n increases so that the measurement resolution improves. The integer n would naturally characterize the inclusions of hyperfinite factors of type II_1 characterized by quantum phase $exp(2\pi/n)$. Finite measurement resolution is expected to give rise to the quantum group representations of symmetries, q-special functions, and q-derivative replacing ordinary derivative and reflecting the presence of discretization.

In p-adic context representation of angle by phases coming as roots of unity corresponds to this as also the hierarchy of effective p-adic topologies reflecting the fact that finite measurement resolution makes well-orderedness of real numbers as un-necessary luxury and one can use much simpler p-adic mathematics. An excellent example is provided by p-adic mass calculations where number theoretical existence arguments fix the predictions of the model based on p-adic thermodynamics to a high degree.

2. Also the numbers of partonic 2-surfaces and string world sheets connecting them give rise to a physical realization of the finite measurement resolution since fermions at string world sheets represent the space-time geometry physically in finite measurement resolution realized also as a hierarchy of geometries for WCW (via the representation of WCW Kähler metric in terms of anti-commutators of super charges). Finite measurement resolution is a property of physical system formed by the observer and system studied: the system studied changes when the resolution changes. 3. This representation is automatically discrete at the level of partonic 2-surfaces, 1-D at their light-like orbits and 4-D in space-time interior. The discretization can be induced from discretization at the level of embedding space as is done in the definition of p-adic variants of space-time surfaces [K145].

For D > 0 the discretization could also take place more abstractly for the parameters characterizing the functions (say coefficients of polynomials) characterizing string boundaries, string world sheets and partonic 2-surfaces, 3-surfaces, and 4-D space-time surfaces. Clearly, an abstraction hierarchy is involved. Similar discretization applied to the parameters characterizing the functions defining the 3-surfaces makes sense at the level of WCW. The discretization is obviously analogous to a choice of gauge and p-adicization suggests that rational numbers and their algebraic extensions give rise to a natural discretization allowing easy algebraic continuation of scattering amplitudes between different number fields.

2.3 Physics As A Generalized Number Theory

Physics as a generalized number theory vision involves actually three threads: p-adic ideas [K125], the ideas related to classical number fields [K126], and the ideas related to the notion of infinite prime [K124].

2.3.1 Fusion Of Real And P-Adic Physics To A Coherent Whole

p-Adic number fields were not present in the original approach to TGD. The success of the padic mass calculations (summarized in the first part of [K86]) made however clear that one must generalize the notion of topology also at the infinitesimal level from that defined by real numbers so that the attribute "topological" in TGD gains much more profound meaning than intended originally. It took a decade to get convinced that the identification of p-adic physics as a correlate of cognition is the most plausible interpretation [K88].

Another idea has been that that p-adic topology of p-adic space-time sheets somehow induces the effective p-adic topology of real space-time sheets. This idea could make physical sense but is not necessary in the recent adelic vision.

The discovery of the properties of number theoretic variants of Shannon entropy led to the idea that living matter could be seen as as something in the intersection of real and p-adic worlds and gave additional support for this interpretation. If even elementary particles reside in this intersection and effective p-adic topology applies for real partonic 2-surfaces, the success of p-adic mass calculations can be understood. The precise identification of this intersection has been a long-standing problem and only quite recently a definite progress has taken place [K142].

The original view about physics as the geometry of WCW is not enough to meet the challenge of unifying real and p-adic physics to a single coherent whole. This inspired "physics as a generalized number theory" approach [K89].

- 1. The first element is a generalization of the notion of number obtained by "gluing" reals and various p-adic number fields and their algebraic extensions along common rationals and algebraics to form a larger adelic structure (see **Fig.** ?? in the appendix of this book).
- 2. At the level of embedding space this gluing could be seen as a gluing of real and p-adic variants of the embedding space together along common points in an algebraic extension of rationals inducing those for p-adic fields to what could be seen as a book like structure. General Coordinate Invariance (GCI) restricted to rationals or their extension requires preferred coordinates for $CD \times CP_2$ and this kind coordinates can be fixed by isometries of H. The coordinates are however not completely unique since non-rational isometries produce new equally good choices.
- 3. The manner to get rid of these problems is a more abstract formulation at the level of WCW: a discrete collection of space-time surface instead of a discrete collection of points of space-time surface. In the recent formulation based on strong form of holography identifying the back of the book as string world sheets and partonic 2-surfaces with parameters in some algebraic extension of rationals, the problems with GCI seem to disappear since the equations for the

2-surfaces in the intersection can be interpreted in any number field. One also gets rid of the ugly discretization at space-time level needed in the notion of p-adic manifold [K145] since it is performed at the level of parameters characterizing 2-D surfaces. By conformal invariance these parameters could be conformal moduli so that infinite-D WCW would effectively reduce to finite-D spaces.

4. The possibility to assign a p-adic prime to the real space-time sheets is required by the success of the elementary particle mass calculations and various applications of the p-adic length scale hypothesis. The original idea was that the non-determinism of Kähler action corresponds to p-adic non-determinism for some primes. It has been however difficult to make this more concrete.

Rational numbers are common to reals and all p-adic number fields. One can actually assign to any algebraic extension of rationals extensions of p-adic numbers and construct corresponding adeles. These extensions can be arranged according to the complexity and I have already earlier proposed that this hierarchy gives rie to an evolutionary hierarchy.

How the existence of preferred p-adic primes characterizing space-time surfaces emerge was solved only quite recently [K142]. The solution relies on p-adicization based on strong holography motivating the idea the idea that string world sheets and partonic surfaces with parameters in algebraic extensions of rationals define the intersection of reality and various p-adicities. The algebraic extension possesses preferred primes as primes, which are ramified meaning that their decomposition to a product of primes of the extension contains higher than first powers of its primes (prime ideals is the more precise notion).

These primes are obviously natural candidates for the primes characterizing string world sheets number theoretically and it might even happen that strong form of holography is possible only for these primes. The weak form of NMP [K80] allows also to justify a generalization of p-adic length scale hypothesis. Primes near but below powers of primes are favoured since they allow exceptionally large negentropy gain so that state function reductions to tend to select them. Therefore the adelic approach combined with strong form of holography seems to be a rather promising approach.

p-Adic continuations of 2-surfaces to 4-surfaces identifiable as imaginations would be due to the existence of p-adic pseudo-constants. The continuation could fail for most configurations of partonic 2-surfaces and string world sheets in the real sector: the interpretation would be that some space-time surfaces can be imagined but not realized [K88]. For certain extensions the number of realizable imaginations could be exceptionally large. These extensions would be winners in the number theoretic fight for survivalandcorresponding ramified primes would be preferred p-adic primes.

The interpretation for discretization the level of partonic 2-surfaces could be in terms of cognitive, sensory, and measurement resolutions rather than fundamental discreteness of the spacetime. At the level of partonic 2-surface the discretization reduces to the naïvely expected one: the corners of string world sheets at partonic 2-surface defined the end points of string and orbits of string ends carrying fermion number. This discretization has concrete physical interpretation. Clearly a co-dimension rule holds. Discretization of n-D object consist of n-2-D objects.

What looks rather counter intuitive first is that transcendental points of p-adic space-time sheets are at spatiotemporal infinity in real sense so that the correlates of cognition cannot be localized to any finite spatiotemporal volume unlike those of sensory experience. The description of cognition in this manner predicts p-adic fractality of real physics meaning chaos in short scales combined with long range correlations: p-adic mass calculations represent one example of p-adic fractality.

The realization of this program at the level of WCW is far from trivial. Kähler-Dirac equation and classical field equations make sense but quantities expressible as space-time integrals - in particular Kähler action- do not make sense p-adically. Therefore one can ask whether only the partonic surfaces in the intersection of real and p-adic worlds should be allowed. Also this restricted theory would be highly non-trivial physically.

2.3.2 Classical Number Fields And Associativity And Commutativity As Fundamental Law Of Physics

The dimensions of classical number fields appear as dimensions of basic objects in quantum TGD. Embedding space has dimension 8, space-time has dimension 4, light-like 3-surfaces are orbits of 2-D partonic surfaces. If conformal QFT applies to 2-surfaces (this is questionable), one-dimensional structures would be the basic objects. The lowest level would correspond to discrete sets of points identifiable as intersections of real and p-adic space-time sheets. This suggests that besides p-adic number fields also classical number fields (reals, complex numbers, quaternions, octonions [A32]) are involved [K126] and the notion of geometry generalizes considerably. In the recent view about quantum TGD the dimensional hierarchy defined by classical number field indeed plays a key role. $H = M^4 \times CP_2$ has a number theoretic interpretation and standard model symmetries can be understood number theoretically as symmetries of hyper-quaternionic planes of hyper-octonionic space.

The associativity condition A(BC) = (AB)C suggests itself as a fundamental physical law of both classical and quantum physics. Commutativity can be considered as an additional condition. In conformal field theories associativity condition indeed fixes the n-point functions of the theory. At the level of classical TGD space-time surfaces could be identified as maximal associative (hyper-quaternionic) sub-manifolds of the embedding space whose points contain a preferred hyper-complex plane M^2 in their tangent space and the hierarchy finite fields-rationals-realscomplex numbers-quaternions-octonions could have direct quantum physical counterpart [K126]. This leads to the notion of number theoretic compactification analogous to the dualities of Mtheory: one can interpret space-time surfaces either as hyper-quaternionic 4-surfaces of M^8 or as 4-surfaces in $M^4 \times CP_2$. As a matter fact, commutativity in number theoretic sense is a further natural condition and leads to the notion of number theoretic braid naturally as also to direct connection with super string models.

At the level of Kähler-Dirac action the identification of space-time surface as a hyperquaternionic sub-manifold of H means that the modified gamma matrices of the space-time surface defined in terms of canonical momentum currents of Kähler action using octonionic representation for the gamma matrices of H span a hyper-quaternionic sub-space of hyper-octonions at each point of space-time surface (hyper-octonions are the subspace of complexified octonions for which imaginary units are octonionic imaginary units multiplied by commutating imaginary unit). Hyper-octonionic representation leads to a proposal for how to extend twistor program to TGD framework [K144, K132].

How to achieve associativity in the fermionic sector?

In the fermionic sector an additional complication emerges. The associativity of the tangentor normal space of the space-time surface need not be enough to guarantee the associativity at the level of Kähler-Dirac or Dirac equation. The reason is the presence of spinor connection. A possible cure could be the vanishing of the components of spinor connection for two conjugates of quaternionic coordinates combined with holomorphy of the modes.

- 1. The induced spinor connection involves sigma matrices in CP_2 degrees of freedom, which for the octonionic representation of gamma matrices are proportional to octonion units in Minkowski degrees of freedom. This corresponds to a reduction of tangent space group SO(1,7) to G_2 . Therefore octonionic Dirac equation identifying Dirac spinors as complexified octonions can lead to non-associativity even when space-time surface is associative or coassociative.
- 2. The simplest manner to overcome these problems is to assume that spinors are localized at 2-D string world sheets with 1-D CP_2 projection and thus possible only in Minkowskian regions. Induced gauge fields would vanish. String world sheets would be minimal surfaces in $M^4 \times D^1 \subset M^4 \times CP_2$ and the theory would simplify enormously. String area would give rise to an additional term in the action assigned to the Minkowskian space-time regions and for vacuum extremals one would have only strings in the first approximation, which conforms with the success of string models and with the intuitive view that vacuum extremals of Kähler

action are basic building bricks of many-sheeted space-time. Note that string world sheets would be also symplectic covariants.

Without further conditions gauge potentials would be non-vanishing but one can hope that one can gauge transform them away in associative manner. If not, one can also consider the possibility that CP_2 projection is geodesic circle S^1 : symplectic invariance is considerably reduces for this option since symplectic transformations must reduce to rotations in S^1 .

3. The fist heavy objection is that action would contain Newton's constant G as a fundamental dynamical parameter: this is a standard recipe for building a non-renormalizable theory. The very idea of TGD indeed is that there is only single dimensionless parameter analogous to critical temperature. One can of coure argue that the dimensionless parameter is $\hbar G/R^2$, R CP_2 "radius".

Second heavy objection is that the Euclidian variant of string action exponentially damps out all string world sheets with area larger than $\hbar G$. Note also that the classical energy of Minkowskian string would be gigantic unless the length of string is of order Planck length. For Minkowskian signature the exponent is oscillatory and one can argue that wild oscillations have the same effect.

The hierarchy of Planck constants would allow the replacement $\hbar \to \hbar_{eff}$ but this is not enough. The area of typical string world sheet would scale as h_{eff} and the size of CD and gravitational Compton lengths of gravitationally bound objects would scale as $\sqrt{h_{eff}}$ rather than $\hbar_{eff} = GMm/v_0$, which one wants. The only way out of problem is to assume $T \propto (\hbar/h_{eff})^2 \times (1/h_{bar}G)$. This is however un-natural for genuine area action. Hence it seems that the visit of the basic assumption of superstring theory to TGD remains very short.

Is super-symmetrized Kähler-Dirac action enough?

Could one do without string area in the action and use only K-D action, which is in any case forced by the super-conformal symmetry? This option I have indeed considered hitherto. K-D Dirac equation indeed tends to reduce to a lower-dimensional one: for massless extremals the K-D operator is effectively 1-dimensional. For cosmic strings this reduction does not however take place. In any case, this leads to ask whether in some cases the solutions of Kähler-Dirac equation are localized at lower-dimensional surfaces of space-time surface.

1. The proposal has indeed been that string world sheets carry vanishing W and possibly even Z fields: in this manner the electromagnetic charge of spinor mode could be well-defined. The vanishing conditions force in the generic case 2-dimensionality.

Besides this the canonical momentum currents for Kähler action defining 4 embedding space vector fields must define an integrable distribution of two planes to give string world sheet. The four canonical momentum currents $\Pi_k \alpha = \partial L_K / \partial_{\partial_\alpha h^k}$ identified as embedding 1-forms can have only two linearly independent components parallel to the string world sheet. Also the Frobenius conditions stating that the two 1-forms are proportional to gradients of two embedding space coordinates Φ_i defining also coordinates at string world sheet, must be satisfied. These conditions are rather strong and are expected to select some discrete set of string world sheets.

- 2. To construct preferred extremal one should fix the partonic 2-surfaces, their light-like orbits defining boundaries of Euclidian and Minkowskian space-time regions, and string world sheets. At string world sheets the boundary condition would be that the normal components of canonical momentum currents for Kähler action vanish. This picture brings in mind strong form of holography and this suggests that might make sense and also solution of Einstein equations with point like sources.
- 3. The localization of spinor modes at 2-D surfaces would would follow from the well-definedness of em charge and one could have situation is which the localization does not occur. For instance, covariantly constant right-handed neutrinos spinor modes at cosmic strings are completely de-localized and one can wonder whether one could give up the localization inside wormhole contacts.

4. String tension is dynamical and physical intuition suggests that induced metric at string world sheet is replaced by the anti-commutator of the K-D gamma matrices and by conformal invariance only the conformal equivalence class of this metric would matter and it could be even equivalent with the induced metric. A possible interpretation is that the energy density of Kähler action has a singularity localized at the string world sheet.

Another interpretation that I proposed for years ago but gave up is that in spirit with the TGD analog of AdS/CFT duality the Noether charges for Kähler action can be reduced to integrals over string world sheet having interpretation as area in effective metric. In the case of magnetic flux tubes carrying monopole fluxes and containing a string connecting partonic 2-surfaces at its ends this interpretation would be very natural, and string tension would characterize the density of Kähler magnetic energy. String model with dynamical string tension would certainly be a good approximation and string tension would depend on scale of CD.

- 5. There is also an objection. For M^4 type vacuum extremals one would not obtain any nonvacuum string world sheets carrying fermions but the successes of string model strongly suggest that string world sheets are there. String world sheets would represent a deformation of the vacuum extremal and far from string world sheets one would have vacuum extremal in an excellent approximation. Situation would be analogous to that in general relativity with point particles.
- 6. The hierarchy of conformal symmetry breakings for K-D action should make string tension proportional to $1/h_{eff}^2$ with $h_{eff} = h_{gr}$ giving correct gravitational Compton length $\Lambda_{gr} = GM/v_0$ defining the minimal size of CD associated with the system. Why the effective string tension of string world sheet should behave like $(\hbar/\hbar_{eff})^2$?

The first point to notice is that the effective metric $G^{\alpha\beta}$ defined as $h^{kl}\Pi_k^{\alpha}\Pi_l^{\beta}$, where the canonical momentum current $\Pi_k \alpha = \partial L_K / \partial_{\partial_\alpha h^k}$ has dimension $1/L^2$ as required. Kähler action density must be dimensionless and since the induced Kähler form is dimensionless the canonical momentum currents are proportional to $1/\alpha_K$.

Should one assume that α_K is fundamental coupling strength fixed by quantum criticality to $\alpha_K = 1/137$? Or should one regard g_K^2 as fundamental parameter so that one would have $1/\alpha_K = \hbar_{eff}/4\pi g_K^2$ having spectrum coming as integer multiples (recall the analogy with inverse of critical temperature)?

The latter option is the in spirit with the original idea stating that the increase of h_{eff} reduces the values of the gauge coupling strengths proportional to α_K so that perturbation series converges (Universe is theoretician friendly). The non-perturbative states would be critical states. The non-determinism of Kähler action implying that the 3-surfaces at the boundaries of CD can be connected by large number of space-time sheets forming *n* conformal equivalence classes. The latter option would give $G^{\alpha\beta} \propto h_{eff}^2$ and $det(G) \propto 1/h_{eff}^2$ as required.

7. It must be emphasized that the string tension has interpretation in terms of gravitational coupling on only at the GRT limit of TGD involving the replacement of many-sheeted space-time with single sheeted one. It can have also interpretation as hadronic string tension or effective string tension associated with magnetic flux tubes and telling the density of Kähler magnetic energy per unit length.

Superstring models would describe only the perturbative Planck scale dynamics for emission and absorption of $h_{eff}/h = 1$ on mass shell gravitons whereas the quantum description of bound states would require $h_{eff}/n > 1$ when the masses. Also the effective gravitational constant associated with the strings would differ from G.

The natural condition is that the size scale of string world sheet associated with the flux tube mediating gravitational binding is $G(M + m)/v_0$, By expressing string tension in the form $1/T = n^2 \hbar G_1$, $n = h_{eff}/h$, this condition gives $\hbar G_1 = \hbar^2/M_{red}^2$, $M_{red} = Mm/(M + m)$. The effective Planck length defined by the effective Newton's constant G_1 analogous to that appearing in string tension is just the Compton length associated with the reduced mass of the system and string tension equals to $T = [v_0/G(M + m)]^2$ apart from a numerical constant (2G(M + m)) is Schwartschild radius for the entire system). Hence the macroscopic

stringy description of gravitation in terms of string differs dramatically from the perturbative one. Note that one can also understand why in the Bohr orbit model of Nottale [E1] for the planetary system and in its TGD version [K117] v_0 must be by a factor 1/5 smaller for outer planets rather than inner planets.

Are 4-D spinor modes consistent with associativity?

The condition that octonionic spinors are equivalent with ordinary spinors looks rather natural but in the case of Kähler-Dirac action the non-associativity could leak in. One could of course give up the condition that octonionic and ordinary K-D equation are equivalent in 4-D case. If so, one could see K-D action as related to non-commutative and maybe even non-associative fermion dynamics. Suppose that one does not.

- 1. K-D action vanishes by K-D equation. Could this save from non-associativity? If the spinors are localized to string world sheets, one obtains just the standard stringy construction of conformal modes of spinor field. The induce spinor connection would have only the holomorphic component A_z . Spinor mode would depend only on z but K-D gamma matrix Γ^z would annihilate the spinor mode so that K-D equation would be satisfied. There are good hopes that the octonionic variant of K-D equation is equivalent with that based on ordinary gamma matrices since quaternionic coordinated reduces to complex coordinate, octonionic quaternionic gamma matrices reduce to complex gamma matrices, sigma matrices are effectively absent by holomorphy.
- 2. One can consider also 4-D situation (maybe inside wormhole contacts). Could some form of quaternion holomorphy [A44] [K132] allow to realize the K-D equation just as in the case of super string models by replacing complex coordinate and its conjugate with quaternion and its 3 conjugates. Only two quaternion conjugates would appear in the spinor mode and the corresponding quaternionic gamma matrices would annihilate the spinor mode. It is essential that in a suitable gauge the spinor connection has non-vanishing components only for two quaternion conjugate coordinates. As a special case one would have a situation in which only one quaternion coordinate appears in the solution. Depending on the character of quaternionion holomorphy the modes would be labelled by one or two integers identifiable as conformal weights.

Even if these octonionic 4-D modes exists (as one expects in the case of cosmic strings), it is far from clear whether the description in terms of them is equivalent with the description using K-D equation based ordinary gamma matrices. The algebraic structure however raises hopes about this. The quaternion coordinate can be represented as sum of two complex coordinates as $q = z_1 + Jz_2$ and the dependence on two quaternion conjugates corresponds to the dependence on two complex coordinates z_1, z_2 . The condition that two quaternion complexified gammas annihilate the spinors is equivalent with the corresponding condition for Dirac equation formulated using 2 complex coordinates. This for wormhole contacts. The possible generalization of this condition to Minkowskian regions would be in terms Hamilton-Jacobi structure.

Note that for cosmic strings of form $X^2 \times Y^2 \subset M^4 \times CP_2$ the associativity condition for S^2 sigma matrix and without assuming localization demands that the commutator of Y^2 imaginary units is proportional to the imaginary unit assignable to X^2 which however depends on point of X^2 . This condition seems to imply correlation between Y^2 and S^2 which does not look physical.

To summarize, the minimal and mathematically most optimistic conclusion is that Kähler-Dirac action is indeed enough to understand gravitational binding without giving up the associativity of the fermionic dynamics. Conformal spinor dynamics would be associative if the spinor modes are localized at string world sheets with vanishing W (and maybe also Z) fields guaranteeing well-definedness of em charge and carrying canonical momentum currents parallel to them. It is not quite clear whether string world sheets are present also inside wormhole contacts: for CP_2 type vacuum extremals the Dirac equation would give only right-handed neutrino as a solution (could they give rise to N = 2 SUSY?). The construction of preferred extremals would realize strong form of holography. By conformal symmetry the effective metric at string world sheet could be conformally equivalent with the induced metric at string world sheets.

Dynamical string tension would be proportional to \hbar/h_{eff}^2 due to the proportionality $\alpha_K \propto 1/h_{eff}$ and predict correctly the size scales of gravitationally bound states for $\hbar_{gr} = \hbar_{eff} = GMm/v_0$. Gravitational constant would be a prediction of the theory and be expressible in terms of α_K and R^2 and \hbar_{eff} ($G \propto R^2/g_K^2$).

In fact, all bound states - elementary particles as pairs of wormhole contacts, hadronic strings, nuclei [L3], molecules, etc. - are described in the same manner quantum mechanically. This is of course nothing new since magnetic flux tubes associated with the strings provide a universal model for interactions in TGD Universe. This also conforms with the TGD counterpart of AdS/CFT duality.

2.3.3 Infinite Primes And Quantum Physics

The hierarchy of infinite primes (and of integers and rationals) [K124] was the first mathematical notion stimulated by TGD inspired theory of consciousness. The construction recipe is equivalent with a repeated second quantization of a super-symmetric arithmetic quantum field theory with bosons and fermions labeled by primes such that the many-particle states of previous level become the elementary particles of new level. At a given level there are free many particles states plus counterparts of many particle states. There is a strong structural analogy with polynomial primes. For polynomials with rational coefficients free many-particle states would correspond to products of first order polynomials and bound states to irreducible polynomials with non-rational roots.

The hierarchy of space-time sheets with many particle states of space-time sheet becoming elementary particles at the next level of hierarchy. For instance, the description of proton as an elementary fermion would be in a well defined sense exact in TGD Universe. Also the hierarchy of n:th order logics are possible correlates for this hierarchy.

This construction leads also to a number theoretic generalization of space-time point since a given real number has infinitely rich number theoretical structure not visible at the level of the real norm of the number a due to the existence of real units expressible in terms of ratios of infinite integers. This number theoretical anatomy suggest a kind of number theoretical Brahman=Atman identity stating that the set consisting of number theoretic variants of single point of the embedding space (equivalent in real sense) is able to represent the points of WCW or maybe even quantum states assignable to causal diamond. One could also speak about algebraic holography.

The hierarchy of algebraic extensions of rationals is becoming a fundamental element of quantum TGD. This hierarchy would correspond to the hierarchy of quantum criticalities labelled by integer $n = h_{eff}/h$, and n could be interpreted as the product of ramified primes of the algebraic extension or its power so that number theoretic criticality would correspond to quantum criticality. The idea is that ramified primes are analogous to multiple roots of polynomial and criticality indeed corresponds to this kind of situation.

Infinite primes at the *n*:th level of hierarchy representing analogs of bound states correspond to irreducible polynomials of *n*-variables identifiable as polynomials of z_n with coefficients, which are polynomials of $z_1, ..., z_{n-1}$. At the first level of hierarchy one has irreducible polynomials of single variable and their roots define irreducible algebraic extensions of rationals. Infinite integers in turn correspond to products of reducible polynomials defining reducible extensions. The infinite integers at the first level of hierarchy would define the hierarchy of algebraic extensions of rationals in turn defining a hierarchy of quantum criticalities. This observation could generalize to the higher levels of hierarchy of infinite primes so that infinite primes would be part of quantum TGD although in much more abstract sense as thought originally.

2.4 Physics As Extension Of Quantum Measurement Theory To A Theory Of Consciousness

TGD inspired theory of consciousness could be seen as a generalization of quantum measurement theory to make observer, which in standard quantum measurement theory remains an outsider, a genuine part of physical system subject to laws of quantum physics. The basic notions are quantum jump identified as moment of consciousness and the notion of self [K76]: in zero energy ontology these notions might however reduce to each other. Negentropy Maximization Principle [K80] defines the dynamics of consciousness and as a special case reproduces standard quantum measurement theory.

2.4.1 Quantum Jump As Moment Of Consciousness

TGD suggests that the quantum jump between quantum histories could identified as moment of consciousness and could therefore be for consciousness theory what elementary particle is for physics [K76].

This means that subjective time evolution corresponds to the sequence of quantum jumps $\Psi_i \to U\Psi_i \to \Psi_f$ consisting of unitary process followed by state function process. Originally U was thought to be the TGD counterpart of the unitary time evolution operator U(-t,t), $t \to \infty$, associated with the scattering solutions of Schrödinger equation. It seems however impossible to assign any real Schrödinger time evolution with U. In zero energy ontology U defines a unitary matrix between zero energy states and is naturally assignable to intentional actions whereas the ordinary S-matrix telling what happens in particle physics experiment (for instance) generalizes to M-matrix defining time-like entanglement between positive and negative energy parts of zero energy states. One might say that U process corresponds to a fundamental act of creation creating a quantum superposition of possibilities and the remaining steps generalizing state function reduction process select between them.

2.4.2 Negentropy Maximization Principle And The Notion Of Self

Negentropy Maximization Principle (NMP [K80]) defines the variational principle of TGD inspired theory of consciousness. It has developed considerably during years. The notion of negentropic entanglement (NE) and Zero Energy Ontology (ZEO) have been main stimuli in this process.

1. U-process is followed by a sequence of state function reductions. Negentropy Maximization Principle (NMP [K80]) in its original form stated that in a given quantum state the most quantum entangled subsystem-complement pair can perform the quantum jump to a state with vanishing entanglement. More precisely: the reduction of the entanglement entropy in the quantum jump is as large as possible. This selects the pair in question and in case of ordinary entanglement entropy leads the selected pair to a product state. The interpretation of the reduction of the entanglement entropy as a conscious information gain makes sense. The sequence of state function reductions decomposes at first step the entire system to two parts in such a way that the reduction entanglement entropy is maximal. This process repeats itself for subsystems. If the subsystem in question cannot be divided into a pair of entangled free system the process stops since energy conservation does not allow it to occur (binding energy).

The original definition of self was as a subsystem able to remain unentangled under state function reductions associated with subsequent quantum jumps. Everything is consciousness but consciousness can be lost if self develops bound state entanglement during U process so that state function reduction to smaller un-entangled pieces is impossible.

2. The existence of number theoretical entanglement entropies in the intersection of real and various p-adic worlds forced to modify this picture. These entropies can be negative and therefore are actually positive negentropies representing conscious or potentially conscious information.

The reduction process can stop also if the self in question allows only decompositions to pairs of systems with negentropic entanglement (NE). This does not require that the system forms a bound state for any pair of subsystems so that the systems decomposing it can be free (no binding energy). This defines a new kind of bound state not describable as a jail defined by the bottom of a potential well. Subsystems are free but remain correlated by NE (see **Fig.** http://tgdtheory.fi/appfigures/cat.jpg or **Fig.** ?? in the appendix of this book).

The consistency with quantum measurement theory demands that quantum measurement leads to an eigen-space of the density matrix so that the outcome of the state function reduction would be characterized by a possibly higher-dimensional projection operator. This would define strong form of NMP. The condition that negentropy gain (rather than final state negentropy) is maximal fixed the sub-system complement pair for which the reduction occurs.

3. Strong form of NMP would mean very restricted form of free will: we would live in the best possible world. The weak form of NMP allows the outcome of state function reduction to be a lower-dimensional subspace of the space defined by the projector. This form of NMP allows free will, event also ethics and moral can be understood if one assumes that NE means experience with positive emotional coloring and has interpretation as information (Akashic records) [K139]. Weak form of NMP allows also to predict generalization of p-adic length scale hypothesis [K142]. Hence weak NMP is much more feasible than strong form of NMP.

It is not at all obvious that NMP is consistent with the second law and it is quite possible that second law holds true only if one restricts the consideration to the visible matter sector with ordinary value of Planck constant.

- 1. The ordinary state function reductions as opposed to those generating negentropic entanglement - imply dissipation crucial for self organization and quantum jump could be regarded as the basic step of an iteration like process leading to the asymptotic self-organization patterns. One could regard dissipation as a Darwinian selector as in standard theories of self-organization. NMP thus predicts that self organization and hence presumably also fractalization can occur inside selves. NMP would favor the generation of negentropic entanglement. This notion is highly attractive since it could allow to understand how quantum self-organization generates larger coherent structures.
- 2. State function reduction for NE is not deterministic for the weak form of NMP but on the average sense negentropy assignable to dark matter sectors increases. This could allow to understand how living matter is able to develop almost deterministic cellular automaton like behaviors.
- 3. A further implication of NMP is that Universe generates information about itself represented in terms of NE: if one is not afraid of esoteric associations one could call this information Akashic records. This is not in obvious conflict with second law since the entropy in the case of second law is ensemble entropy assignable to single particle in thermodynamical description.

The simplest assumption is that the information measured by number theoretic negentropy is experienced during the state function reduction sequence at fixed boundary of CD defining self.

Weak NMP provides an understanding of life, which is the mirror image of that believed to be provided by the second law. Life in the standard Universe would be a thermodynamical fluctuation - the needed size of this fluctuation has been steadily increasing and it seems that it will eventually fill the entire Universe! Life in TGD Universe is a necessity implied by NMP and the attribute "weak" makes possible the analogs of thermodynamical fluctuations in opposite effects meaning that the world is not the best possible one. On the other hand, weak form of NMP implies evolution as selection of preferred p-adic primes since the free will allows also larger negentropy gains than strong form of NMP.

2.4.3 Life As Islands Of Rational/Algebraic Numbers In The Seas Of Real And P-Adic Continua?

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 words, 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 defined 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 [K6]. Livingdead 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 [K108].

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.

2.4.4 Two Times

The basic implication of the proposed view is that subjective time and geometric time of physicist are not the same [K76]. This is not a news actually. Geometric time is reversible, subjective time irreversible. Geometric future and past are in completely democratic position, subjective future does not exist at all yet. One can say that the non-determinism of quantum jump is completely outside space-time and Hilbert space since quantum jumps replaces entire 4-D time evolution (or rather, their quantum superposition) with a new one, re-creates it. Also conscious existence defies any geometric description. This new view resolves the basic problem of quantum measurement theory due to the conflict between determinism of Schrödinger equation and randomness of quantum jump. The challenge is to understand how these two times correlate so closely as to lead to their erratic identification.

With respect to geometric time the contents of conscious experience is naturally determined by the space-time region inside CD in zero energy ontology. This geometro-temporal integration should have subjecto-temporal counterpart. The experiences of self are determined partially by the mental images assignable to sub-selves (having sub-CDs as embedding space correlates) and the quantum jump sequences associated with sub-selves define a sequence of mental images.

The view about the experience of time has changed.

- 1. The original hypothesis was that self experiences these sequences of mental images as a continuous time flow. If the mental images define the contents fo consciousness completely, self would experience in absence of mental images experience of "timelessness". This could be seen to be in accordance with the reports of practitioners of various spiritual practices. One must be however extremely cautious and try to avoid naïve interpretations.
- 2. ZEO forces to modify this view: the experience about the flow of time and its arrow corresponds to a sequence of repeated state function reductions leaving the state at fixed boundary of CD invariant: in standard quantum theory the entire state would remain invariant but now the position of the upper boundary of CD and state at it changes. Perhaps the experiences of meditators are such that the upper boundary of CD is more or less stationary during them.

What happens when consciousness is lost?

- 1. The original vision was that self loses consciousness in quantum jump generating entropic entanglement and experience an expansion of consciousness if the resulting entanglement is negentropic.
- 2. The recent vision is that the first state function reduction to the opposite boundary of CD means for self death followed by re-incarnation at the opposite boundary.

The assumption that the integration of experiences of self involves a kind of averaging over sub-selves of sub-selves guarantees that the sensory experiences are reliable despite the fact that quantum nondeterminism is involved with each quantum jump.

The measurement of density matrix defined by the MM^{\dagger} , where M is the M-matrix between positive and negative energy parts of the zero energy state would correspond to the passive aspects of consciousness such as sensory experiencing. U would represent at the fundamental level volition as a creation of a quantum superposition of possibilities. What follows it would be a selection between them. The volitional choice between macroscopically differing space-time sheets representing different maxima of Kähler function could be basically responsible for the active aspect of consciousness. The fundamental perception-reaction feedback loop of biosystems would result from the combination of the active and passive aspects of consciousness represented by U and M.

2.4.5 How Experienced Time And The Geometric Time Of Physicist Relate To Each Other?

The relationship between experienced time and time of physicist is one of the basic puzzles of modern physics. In the proposed framework they are certainly two different things and the challenge is to understand why the correlation between them is so strong that it has led to their identification. One can imagine several alternative views explaining this correlation [K139, K13] and it is better to keep mind open.

Basic questions

The flow of subjective time corresponds to quantum jump sequences for sub-selves of self having interpretation as mental images. If mind is completely empty of mental images subjectively experienced time ceases to exists. This leaves however several questions to be answered.

- 1. Why the contents of conscious of self comes from a finite space-time region looks like an easy question. If the contents of consciousness for sub-selves representing mental images is localized to the sub-CDs with indeed have defined temporal position inside CD assigned with the self the contents of consciousness is indeed from a finite space-time volume. This implies a new view about memory. There is no need to store again and again memories to the "brain now" since the communications with the geometric past by negative energy signals and also time-like negentropic quantum entanglement allow the sharing of the mental images of the geometric past.
- 2. There are also more difficult questions. Subjective time has arrow and has only the recent and possibly also past. The subjective past could in principle reduce to subjective now if conscious experience is about 4-D space-time region so that memories would be always geometric memories. How these properties of subjective time are transferred to apparent properties of geometric time? How the arrow of geometric time is induced? How it is possible that the locus for the contents of conscious experience shifts or at least seems to be shifted quantum jump by quantum jump to the direction of geometric future? Why the sensory mental images are located in a narrow time interval of about .1 seconds in the usual states of consciousness (not that sensory memories are possible: scent memories and phantom pain in leg could be seen as examples of vivid sensory memory)?

The recent view about arrow of time

The basic intuitive idea about the explanation for the arrow of psychological time has been the same from the beginning - diffusion inside light-cone - but its detailed realization has required understanding of what quantum TGD really is. The replacement of ordinary positive energy ontology with zero energy ontology (ZEO) has played a crucial role in this development. The TGD based vision about how the arrow of geometric time is by no means fully developed and final. It however seems that the most essential aspects have been understood now.

- 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 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 or only correlate with it?
- 2. The state function reductions can occur at both 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!

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.

3. This approach codes also the arrow of time at the space-time level: the average spacetime 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. 4. In principle the arrow of time can temporarily change but it would seem that this can occur in very special circumstances and probably takes place in 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.

Usually it is thought that the increase of ensemble entropy implied by second law gives rise to the arrow of observed time. In TGD framework NMP replaces second law as a fundamental principle and at the level of ensembles implies it. The negentropy assignable to entanglement increases by NMP if one accept the number of number theoretic Shannon entropy.

Could the increase of entanglement negentropy define the arrow of time? Negentropy is assignable to the fixed boundary of CD and characterizes self. The sequence of repeated state function reductions cannot therefore increase negentropy. Negentropy would increase only in the state function reduction a the opposite boundary of CD and the increased negentropy would be associated the re-incarnated self. The increase of negentropy would be forced by NMP and also the size scale of CD would increase.

This would be certainly consistent with evolution. The prediction is that a given CD corresponds to an entire family CDs coming integer multiples $n = h_{eff}/h$ of a minimal size. During state function reduction sequence to fixed boundary of CD the average size defined by average value of n and p-adic length scale involved would increase in statistical sense. One can consider also the possibility that there is sharp localization to given value of n.

The periods of repeated state function reductions would be periods of coherence (sustained mental image, subself) and decoherence would be implied by the first state function to the opposite boundary of CD forced by NMP to eventually to occur. At the level of action principle the increase of h_{eff} means gradual reduction of string tension $T \propto 1/\hbar_{eff}G$ and generation of gravitationally bound states of increasing size with binding realized in terms of strings connecting the partonic 2-surfaces. Gravitation, biology, and evolution would be very intimately related.

2.5 Implications Of Quantum Classical Correspondence

Quantum Classical Correspondence has been of the guiding principles in the construction of Quantum TGD. Recall that at the level of WCW Quantum TGD is a theory of purely classical spinor fields. In ZEO the modes of sub- WCW spinor fields associated with a given CD have by effective 2-dimensionality as their arguments collections of partonic 2-surfaces and their 4-D tangent space data. U-matrix, M-matrices, and S-matrix are in principle reducible to the properties of the basis of WCW spinor fields [K85].

Quantum classical correspondence assumes that classical dynamics defined by the preferred extremals of Kähler action define an exact part of Quantum TGD. More generally, all quantum notions - even the quantum jump sequence characterizing the contents of consciousness - must have space-time counterpart: this representation is analogous to written language.

The notion of WCW Kähler geometry combined with GCI allows to identify classical spacetime surfaces as analogs of Bohr orbits as preferred extremals of Kähler action. What "preferred" means is of course a highly non-trivial question. Assuming that light-like 3-surfaces and space-like 3-surfaces at the ends of CDs give rise to same theory implies effective 2-dimensionality and strong form of holography having dramatic implications for the theory.

2.5.1 Strong Form Of Holography And Effective 2-Dimensionality

Strong form of holography reduces to strong form of General Coordinate Invariance.

1. The starting point is the vision about geometrization of quantum physics in terms of the geometry of WCW, the space of 3-surfaces of H. Quantum states correspond to classical WCW spinor fields and WCW spinors (spinor field at given point of WVW, which is 3-surface!). No quantization occurs at WCW level: spinor fields are classical. WCW spinor corresponds to fermionic Fock states with fermionic oscillator operators associated with free second quantized induced spinor fields (spinor fields of H) at 3-surfaces and extended to

4-surfaces. This "second quantization" has purely geometric meaning and makes possible WCW spinor geometry.

2. General Coordinate Invariance is one of the fundamental symmetries and states that 4-D general coordinate transformations act as gauge symmetries. This requires that the definition of WCW metric assigns to 3-D surface a 4-D space-time surface. This space-time surface is analogous to Bohr orbit and defines the "classical physics" associated with the 3-surface but satisfying the analogs of Bohr quantization rules. This space-time surface is a preferred extremal of Kähler action and the value of Kähler action for the Euclidian regions of space-time surface defines Kähler function defining the Kähler metric of WCW.

The value of Kähler action for Minkowskian regions of space-time surface defines a complex phase in vacuum functional and plays a role of Morse function and is also analogous to the action in ordinary quantum field theory: in particular it makes possible interference effects at the level of vacuum functional central in quantum field theories.

Obviously the effective reduction of 4-D theory to 3-D theory corresponds to holography. In ordinary QFT approach to TGD this would not take place since one performs path integral over all space-time surfaces. In fact, the total failure of this approach led to the generalization of Einstein's geometrization program of classical physics to a geometrization of quantum physics in terms of WCW geometry.

Characterizing the mathematical conditions satisfied by the preferred extremals of Kähler action precisely is still one of the basic mathematical challenges and several conjectures have been made during years.

3. GCI makes possible to fix the gauge by choosing the 3-surfaces in some especially convenient manner. One choice is as unions of space-like 3-surfaces at the light-like boundaries of CDs. Second choice is as wormhole throats which are light-like 3-surfaces at which the signature of the induced metric changes from Euclidian to Minkowskian and behaving in many respects like causal horizons and black hole horizons. Which of the choices is correct or are both correct? If both choices are correct one ends up with the strong form of GCI: the intersections of 3-D light-like wormhole throats with the 3-D space-like ends of space-time surface defining partonic 2-surfaces and their 4-D tangent space data carry information about quantum states.

Strong form of GCI implies strong form of holography. Already partonic 2-surfaces and their 4-D tangent space data are enough. This does not mean genuine 2-dimensionality and reduction to a string theory since tangent space data are needed. Also the breaking of strict determinism for Kähler action implies that the effective 2-dimensionality is true only in some length scales.

2.5.2 Weak Form Of Electric Magnetic Duality

The notion of electric-magnetic duality [B3] was proposed first by Olive and Montonen and is central in $\mathcal{N} = 4$ supersymmetric gauge theories. It states that magnetic monopoles and ordinary particles are two different phases of theory and that the description in terms of monopoles can be applied at the limit when the running gauge coupling constant becomes very large and perturbation theory fails to converge. The notion of electric-magnetic self-duality is more natural since for CP_2 geometry Kähler form is self-dual and Kähler magnetic monopoles are also Kähler electric monopoles and Kähler coupling strength is by quantum criticality renormalization group invariant rather than running coupling constant. The notion of electric-magnetic (self-)duality emerged already two decades ago in the attempts to formulate the Kähler geometric of WCW. Quite recently a considerable step of progress took place in the understanding of this notion [K39]. What seems to be essential is that one adopts a weaker form of the self-duality applying at partonic 2-surfaces [K37].

Every new idea must be of course taken with a grain of salt but the good sign is that this concept leads to precise predictions. The point is that elementary particles do not generate monopole fields in macroscopic length scales: at least when one considers visible matter. The first question is whether elementary particles could have vanishing magnetic charges: this turns out to be impossible. The next question is how the screening of the magnetic charges could take place and leads to an identification of the physical particles as string like objects identified as pairs magnetic charged wormhole throats connected by magnetic flux tubes.

- 1. The first implication is a new view about electro-weak massivation reducing it to weak confinement in TGD framework. The second end of the string contains particle having electroweak isospin neutralizing that of elementary fermion and the size scale of the string is electro-weak scale would be in question. Hence the screening of electro-weak force takes place via weak confinement realized in terms of magnetic confinement.
- 2. This picture generalizes to the case of color confinement. Also quarks correspond to pairs of magnetic monopoles but the charges need not vanish now. Rather, valence quarks would be connected by flux tubes of length of order hadron size such that magnetic charges sum up to zero. For instance, for baryonic valence quarks these charges could be (2, -1, -1) and could be proportional to color hyper charge.
- 3. The highly non-trivial prediction making more precise the earlier stringy vision is that elementary particles are string like objects in the length scale defined by their Compton length. Since the other end of flux tube carries neutrino pair it is however essentially invisible at low energies so that there is no obvious conflict with experimental facts.

The hierarchy of Planck constants means that the Compton lengths of dark elementary particles can be macroscopic so that their character as magnetic flux tubes with monopoles at ends could make itself manifest in condensed and living matter.

2.5.3 TGD As Almost Topological QFT

TGD as almost topological QFT is one of those idea that one cannot be sure of. I think it emerged around 2005. I have been even ready to give it up but it experienced re-incarnation as I discovered the weak form of electric-magnetic duality.

- 1. Holography in the sense that data at 3-D surfaces code for the quantum state is an idea which emerged already at 1990 or so since 3-surfaces are indeed basic objects in quantum TGD. General Coordinate Invariance indeed implies this and the highly non-trivial implication is that space-time surface associated with a given 3-surface is analogous to Bohr orbit. Therefore semiclassical quantization is an exact part of quantum TGD.
- 2. The question is whether it is light-like 3-surfaces or space-like 3-surfaces at the ends of spacetime sheet defined by CD can be identified as the 3-surfaces that carry the data. Strong form of General Coordinate Invariance states that both choices are equally good. Only the intersections of these surfaces at the boundaries of CDs and their 4-D tangent spaces carry the data. This implies effective 2-dimensionality and strongly suggests conformal invariance and coset representation meaning that the actions of conformal generators of light-like 3surface and those associated with the boundary of CD cancel each other. This implies EP in generalized form.
- 3. Already effective 3-dimensionality suggests but does not imply that the Kähler action reduces to 3-D Chern-Simons term. If this occurs, the theory simplifies enormously calculationally and there are good hopes of calculating even without knowing details about preferred extremals. Chern-Simons action defines a topological QFT for braids and braids indeed replaced the 3-D light-like orbits of partonic 2-surfaces in TGD Universe in finite measurement resolution.

The reduction of Kähler action to 3-D integrals

To achieve reduction to Chern-Simons term the Kähler action for preferred extremals must reduce to a total divergence. This is achieved if in the decomposition of action to a total divergence and term $j \cdot A$, where j is Kähler current the latter term vanishes: $j \cdot A = 0$. This takes place in the following situations.

1. Empty space Maxwell equations j = 0 stating the vanishing of Kähler current hold true.

- 2. *j* and *A* are light-like and in the same direction so that their product vanishes. This is true for so called "massless extremals" (topological light rays).
- 3. j is proportional to the instanton current $j = \Phi j_I$, $j_I = \epsilon^{\alpha\beta\gamma\delta}A_\beta J_{\gamma\delta}$ so that $j \cdot A$ vanishes identically. Conservation of the Kähler current requires that the proportional factor Φ must satisfy $d\Phi \cdot j_I + \Phi I = 0$ where I is instanton density. $d\Phi$ is either orthogonal to j_I or both $d\Phi$ and j_I are light-like and have same direction.

This kind of proportionality might hold true also for other isometry currents and would mean "topologicalization" of conserved currents in accordance with the idea about almost topological QFT.

One also ends up with the proposal that preferred extremals are such that the flow lines of isometry currents integrate to coordinate lines globally. This kind of flow is known as Beltrami flow. This would mean that they define the analog of hydrodynamic flow in which the orbits of particles do not cross each other and there are no collisions. The analog of quantum flow (no collisions - no dissipation) would be in question and one could assign to the flow an order parameter of a supra phase varying only along the flow lines. The basic condition for a flow J to define Beltrami flow read as $J \wedge dJ = 0$, where J is the 1-form defined by the current (covariant form of current depending on induced metric).

Reduction to Chern-Simons term by the weak form of electric-magnetic duality

The proportionality of Kähler current to instanton current implies the reduction of action to 3-D terms but not yet a reduction to Chern-Simons terms implying almost topological QFT property.

- 1. This is guaranteed if one assumed what I have called weak form of electric-magnetic duality. This duality generalizes the Montonen-Olive electric-magnetic duality and would hold at wormhole throats and space-like 3-surfaces at the ends of space-time sheets but not necessarily elsewhere. It would imply that Kähler flux equals to magnetic flux so that Kähler electric charge is quantized. There are good reasons to assume that this charge corresponds to fermion number so that all wormhole throats carrying fermion number would be magnetic monopoles carrying Kähler magnetic charge equal to fermion number. Physical particles would correspond to multi-monopole states with vanishing total Kähler magnetic charge.
- 2. It is important to notice that the weak form of electric-magnetic duality at the space-like 3-surfaces and wormhole throats involves the induced metric of the space-time sheet so that metric does not disappear from the theory although Kähler action reduces to Chern-Simons term. This gives a precise content to the attribute "almost". The reduction to Chern-Simons terms would mean enormous calculational simplification of the theory and raises the hope that the theory could be calculable.
- 3. This also fixes to a high degree the view about leptons and hadrons. For instance, leptons should be string like objects formed by Kähler magnetically charged wormhole throats connected by magnetic flux tubes. Analogous picture applies to gauge bosons consisting of wormhole contacts with throats carrying fermion and anti-fermion numbers respectively. Hadrons could correspond multimonopole states.

Morse, Kähler, and me

First year physics student would immediately say that $\sqrt{g_4}$ is imaginary in the space-time regions with Minkowskian signature of the induced metric and real otherwise. For me it took 33 years to finally accept this trivial fact as a fact but finally I had to give up! This simple fact implies that Minkowskian regions give imaginary exponent of Chern-Simons term and Euclidian regions real exponent of Chern-Simons term [K79]. Under rather natural assumptions the two Chern-Simons terms are identical and would be obtained as an exponent of Chern-Simons term multiplied by complex number.

The imaginary exponent gives rise to interference effects typical for gauge theories and defining the core mechanism of quantum field theories and implies that stationary phase approximation makes sense. Stationary phase approximation is important also in topological QFTs and Chern-Simons term plays the role of Morse function in topological QFTs classifying the topological of 4-manifolds. The real exponent defines Kähler function and guarantees the convergence of the functional integral and guarantees that it exists as a genuine mathematical object.

Could Kähler action reduce to a 2-D integral?

Effective 2-dimensionality suggests a further dimensional reduction in the sense that Chern-Simons terms might allow expression as 2-dimensional integrals. If this idea is accepted, the only natural option is a reduction to a sum of areas of string world sheets with dynamical string tension. I have indeed developed a detailed proposal concerning the identification of this string world sheet [K132]. String world sheets indeed emerge naturally in quantum TGD and have as their boundary the space-like braid strands at the ends of space-time surfaces and light-like braid strands at the light-like 3-surfaces. Knotting of string world sheets is possible in 4-D space-time whereas braid strands link and knot at 3-surfaces so that quantum TGD would provide a theory of ordinary knots and 2-knots. This adds additional aspect to the statement that TGD is almost topological QFT.

2.5.4 Generalized Feynman Diagrams And Braids

The notion of generalized Feynman diagram [K66, K132, K57] has been developing rapidly during last five years. This progress has been boosted by several developments. The basic observation is that the regions of space-time surface with Euclidian signature of induced metric can be identified as generalized Feynman diagrams. Same interpretation applies by holography also to the light-like 3-surfaces at which the signature of the induced metric changes from Euclidian to Minkowskian. Additional boosts are due to ZEO allowing to interpreted the Feynman diagrams as a characterization of zero energy states. Also strong form of holography, bosonic energence, finite measurement resolution realized as discretization allows to replaced space-time sheets with string world sheets with the ends of string world sheets realized as braid strands, the realization that knotting of these strings is possible and could play a key role, and the connection with twistor approach have been important stimuli. The special role of 10 Hz frequency assignable to electron suggests that generalized Feynman diagrams could be relevant also for TGD inspired biology.

ZEO together with the notion of bosonic emergence leads to a new view about Feynman diagrams. The new element is that all physical states consist basically of wormhole throats which carry light-like four-momentum. Even virtual momenta are light-like and space-like four-momenta are obtained for wormhole contacts for which the energies of light-like states are of opposite sign. This leads to very powerful constraints on loop diagrams and there are good reasons to believe that both UV and IR divergences are absent.

Finite measurement resolution allows to assign braid strands to the light-like 3-surfaces and string world sheets to the 4-surfaces and one can also identify the braid strands as lines of generalized Feynman diagrams. It is possible to distinguish between light-like braids assignable to the light-like 3-surfaces and space-like braids connecting different partonic 2-surfaces at the ends of the space-time surface at the boundary of CD. Braids have also direct biological significance. DNA as topological quantum computer [K6] utilizes both kinds of braidings.

2.5.5 The Superposition Of Classical Fields In TGD Universe

Living system as conscious hologram is one of the basic visions. What one means with classical fields, their interference, and their interaction with elementary particles is an very essential aspect of what it is to be a hologram and a clarification to this issued emerged only during last year. As a matter fact, basic objection against TGD is that the interference of classical fields in the usual sense is not possible in TGD Universe!

In TGD Universe gauge fields are replaced with topological field quanta. Examples are topological light rays, magnetic/electric flux tubes and sheets, and 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 the basic topological operations for flux quanta.

The basic question is how the basic notions assigned with the classical gauge and gravitational fields understood in standard sense generalize in TGD framework.

- 1. Superposition and interference of the classical fields is very natural in Maxwell electrodynamics and certainly experimentally verified phenomena. Also the notion of hologram relies crucially on the notion of interference. How can one describe the effects explained in terms of superposition of fields in a situation in which the theory is extremely non-linear and all classical gauge fields are expressible in terms of CP_2 coordinates and their gradients? It is also rather clear that the preferred extremals for Kähler action decompose to space-time regions representing space-time correlates for quanta. The superposition of classical fields in Maxwellian sense is impossible.
- 2. How can one cope with this situation? The answer is based on simple observation: only the *effects* of the classical fields superpose. There is no need for the fields to superpose. Together with the notion of many-sheeted space-time this leads to elegant description of interference effects without any need to assume that linearization is a good approximation.
- 3. Topological quantization brings in also braiding and reconnection of magnetic flux tubes as basic operations for classical fields. These operations for flux tubes have also Maxwellian counterparts at the level of field lines. Braiding and reconnection are in a central role in TGD Universe and especially so in in TGD inspired theory of consciousness and quantum biology. The challenge is to build a coherent overall phenomenological view about the role of topologically quantized classical fields in biology and neuroscience. For instance, one can ask what is the precise formulation for the notion of conscious hologram and whether magnetic flux tubes could serve as correlates of entanglement (or at least negentropic entanglement suggested by the number theoretic vision and identified as a basic signature of living matter).
- 4. Topological quantization and the notion of magnetic body are especially important in TGD inspired model of EEG. The attempt to understand the findings of Persinger from the study of what is known as God helmet leads to a considerable progress in the understanding the possible role of topologically quantized classical fields in biology and neuro-science.

The replacement of superposition of fields with superposition of their effects allows to understand also how the many-sheeted space-time of TGD relates to the space-time of general relativity. GRT space-time seen as an effective space-time obtained by replacing Minkowskian regions of many-sheeted space-time with a region of Minkowski space with effective metric determined as a sum of Minkowski metric and sum over the deviations of the induced metrics of space-time sheets from Minkowski metric. Poincare invariance suggests strongly classical form of Equivalence Principle realized in terms of Einstein's equation for the GRT limit in long length scales at least.

One can consider also 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 very large cosmological constant in Einstein-Maxwell theory. Also the gauge potentials of the standard model correspond classically to superpositions of induced gauge potentials over space-time sheets and standard model follows naturally at the QFT limit of TGD. TGD can be seen as a microscopic theory with space-time sheets carrying extremely simple "archetypal" field patterns and arranged in complex manner to many-sheeted space-time topologies whereas GRT and QFT represents long length scale limit with topological complexity replaced with the complexity of fields patterns.

For the induced gauge fields coupling constants are absorbed into the definition of gauge potentials so that coupling constant evolution does not make sense in TGD space-time. Coupling constant evolution characterizing quantum field theories makes in TGD framework sense as the dependence of various vertices on the size scale of causal diamond (CD). This discrete coupling constant evolution becomes at QFT and GRT limits continuous coupling constant evolution.

Chapter 3

Quantum Mind in TGD Universe

3.1 Introduction

The notion of Quantum Mind [J84] has become a respected branch of science during thirty years since Esalem conference. The basic vision is that quantum superposition, quantum entanglement and state function reduction (or some of its interpretational equivalents) are somehow highly relevant for the understanding of consciousness. Whether quantum entanglement or quantum jump or something else is identified as a correlate for consciousness depends on theorist.

The basic objections against Quantum Mind is that standard quantum physics - at least wave mechanics- leaves no room for quantum mind. Decoherence leading to a loss of entanglement is the basic enemy of quantum mind [J87]. Experimental work however suggests that macroscopic quantum coherence prevails in cell length scale: the findings about photosynthesis provide an example of this [I25]. There is also a growing evidence for macro-entanglement between different brains correlating closely with electromagnetic fields [J95, J44].

Of course, the idea that wave mechanics is enough to describe living matter and also the belief that quantum theory - as we know it - is something final are only beliefs. There are many other similar beliefs: the belief on reductionism coded to the statement that everything above intermediate boson length scale is understood in recent day physics; the belief that living matter differs from inanimate matter only because it is very complex; the belief that experienced time and the geometric time of physicist are one and the same thing; the pragmatic belief that the problems of quantum measurement theory can be forgotten by saying that quantum theory is just a calculational recipe;...

One could add one further not quite obvious item to the list. Dark matter and dark energy are one of the most notorious problems of recent day physics and it is just a belief that dark matter is nothing but some exotic X-ino having very weak interactions with visible matter and therefore does not have any relevance for the understanding of living matter.

The basic message of this article is that standard quantum theory is not enough if one wants to construct a theory of Quantum Mind. A profound re-evaluation of the belief system underlying the ontology of the recent day quantum physics is needed. My own proposal is following.

- The reductionistic dogma is replaced with fractality meaning infinite hierarchies both at the level of matter and mind. Consciousness is everywhere in a form of self hierarchy so that Quantum Mind involves more than brain. Biological bodies, cells, biomolecules, and even elementary particles correspond to the levels of the self hierarchy. Also higher collective levels are present.
- Topological field structures implied by the new fractal view about space-time I speak about many-sheeted space-time- are essential parts of this hierarchy. The notion of field (or magnetic) body is one aspect of the many-sheeted space-time and one could even say that magnetic body is the intentional agent using biological body as a motor instrument and sensory receptor. EEG and its various fractal analogs can be seen as communication and control tools of the magnetic body in this conceptual framework. The explanation for the strange time delays associated the passive aspects of consciousness discovered by Libet [J42] and
the good hopes about understanding of fundamental biorhythms in terms of cyclotron frequencies of biologically important and Josephson frequencies assignable to cell membrane Josephson junctions [K48] provide support for this vision. This conforms with the proposals that spin and more generally angular momentum are central for understanding consciousness and living matter [J72, J95]. Biological evolution becomes evolution of consciousness and one cannot restrict Quantum Mind to microtubules, brain, or even biological body.

- Self hierarchy has two physical correlates: the hierarchy of p-adic length scales and the hierarchy of Planck constants: both hierarchies have experimental support. A number theoretical miracle occurs: the length scale range 10 nm-2.5 μ m involves as many as four electron Compton scales assignable to Gaussian Mersennes. The effects of ELF em fields on vertebrate brain [J23] and the strange behavior of cell membrane and cell interior suggesting strongly quantal ionic currents [I82] provide physical support for both the hierarchy of Planck constants and p-adic length scale hypothesis.
- In TGD Universe zero energy ontology (ZEO) replaces the positive energy ontology of standard physics. The motivation comes both certain philosophical dilemma which is very frustrating for a theoretician, and the crossing symmetry of quantum field theory justifies ZEO. ZEO assigns new macroscopic time scale to each elementary particle. For electron and quarks these time scale coincide with fundamental biological time scales (for instance, the.1 second time scale predicted for electron corresponds to 10 Hz fundamental biorhythm). Elementary particle physics and biology are therefore strongly interrelated in ZEO.
- The identification of quantum jump as moment of consciousness and the notion of self emerge from a generalization of quantum measurement theory to a theory of consciousness. In this framework the experienced time identified as a sequence of quantum jumps and the geometric time of physicist cannot be identified [?]

The fact that the contents of conscious experience is about a four-dimensional region of spacetime implies a new interpretation of memories [K106]. Quantum jump replacing the entire geometric future and past with a new one: Libet's strange findings about active aspects of consciousness [J15] forcing in positive energy ontology the conclusion that free will is illusion provide support for this view. The challenge is to understand the arrow of time and why the contents of sensory experience is localized to a rather short time interval of about.1 second: this suggests a rather dramatic radical idea about how the arrow of subjective time emerges as a consequence of Negentropy Maximization Principle [K80] defining the basic variational principle of TGD inspired theory of consciousness.

• p-Adic physics extending reality to include also various p-adic levels is highly relevant for the understanding of the difference between living and inanimate matter. Negentropic entanglement is possible for p-adic variant of Shannon entropy making sense if entanglement probabilities are algebraic. One can say that this entanglement is possible in the intersection of real and p-adic worlds in which intentions could transform to actions by quantum jumps replacing p-adic space-time sheets with real ones (this makes sense only in ZEO!). Maybe this is the mathematical and information theoretical quintessence of life.

Before continuing a comment about the notion of consciousness is in order. This notion as also the notion of awareness implicitly codes for the assumption that consciousness is a property of a physical system- something mathematically analogous to mass or charge. The greek world "nous" and finnish word "tajunta" refer to activity rather than property and this meaning is more appropriate in TGD framework. Since it would sound rather artificial to talk about "TGD inspired theory of nous", I will will use the standard term in the sequel although it is misleading. It should be also emphasize that I represent only those aspects of a rather extensive work documented in the books at my homepage, which seem to be especially interesting just now. In the following representation I am forced to leave out all details. They can be found in the books about TGD inspired theory of consciousness at my homepage [K131, K25, K97, K60, K24, K71, K75, K120]. I have also summarized TGD inspired theory of consciousness in an issue of tgd [L7, L6, L5] but from different view point. 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 [L31].

3.2 What Are The Problems Of Quantum Mind Theories?

In the following I list briefly the basic problems of physics and quantum mind theories using a classification which is rather natural from the point of view of physics.

3.2.1 Some Philosophical Problems Of Quantum Physics

"Monism, dualism, or something else?" is the first basic question. Monism appears as two variants which are mirror images. Materialism has the problem that consciousness becomes something totally reducible to the state of material system so that free will must be an illusion if one believes in the deterministic laws of physics. This is in a sharp contrast to what we directly experience. In the idealistic framework one loses completely physics. The difficulty of dualism- pointed out very clearly by Chalmers [J25] - is that it is very difficult to achieve consistency with the basic laws of physics which do not allow free will. It seems that one must have something new allowing to achieve consistency of the determinism of field equations with (partially) free will.

"Reductionism or not?" is second key question. For me personally the realization that reductionism is a mere dogma was a painful process although it was from the beginning clear that TGD based view about space-time forces to challenge this belief. It was especially painful to take seriously the fact that even the reduction of chemical bond to wave mechanics alone is nothing but a belief since it it is not yet testable by performing numerical calculations. Gradually I became conscious about the many non-existing bridges of reductionism: the bridge from quarks and gluons to hadrons; the bridge from nucleons to nuclei; the bridge from atoms to molecules; the bridges from inorganic chemistry to organic chemistry to biochemistry: all these bridges are just figments of wishful thinking and implications of the reductionistic dogma rather than support for it. Also the widely accepted argument about living matter as something which is just complex fails to be distinguishable from a rhetoric trick.

"Determinism or not?" is the third question. Also here it took time to realize that the belief that free will is an illusion does not reflect the reality but our limited tools for describing it. The physicists of previous centuries did not have any conceptual and mathematical tools to describe free will without giving up the idea about laws of physics. Most importantly, they did not know anything about quantum non-determinism. Perhaps it is some kind of cognitive inertia that physicists have been ready to give up even the very notion of objective reality instead of accepting the fact that non-determinism is real and concluding that one should find an ontology consistent with both quantum non-determinism and Schrödinger equation.

- The notion of time is highly problematic.
 - The relationship between experienced time and the geometric time of physicist is poorly understood. Subjective time is irreversible and has only recent moment and past, geometric time is reversible and spans entire eternity. The assignment of experienced time with a 3-D wave front shifting in the direction of geometric time direction is in conflict with Lorentz symmetry and general coordinate invariance, which do not allow to identify a unique time coordinate as the subjective time. The natural basic object in general relativity is 4-dimensional space-time region, not time=constant snapshot.
 - In physics conceptual difficulties are encountered already in the phenomenological description of dissipation by adding to the reversible field equations phenomenological dissipation terms. Rather remarkably, the quantum mechanical formulas for the reaction rates in terms used to calculated dissipation coefficients involve integral over entire space-time so that quantum events have at least formally an infinite duration. Finite duration is certainly necessary by Uncertainty Principle. Somehow quantum jump seems

to involve entire geometric eternity: as if it would take place between two geometric eternities.

- There is also the problem of initial state. If the dynamics is deterministic and conservation laws hold, only a single solution of field equations is realized in classical physics and theoretical physics becomes useless waste of time since it cannot be tested. If quantum non-determinism is allowed, conservation laws still restrict the physical states to those having fixed net values. "What was the initial state at the moment of Big Bang?" is the question which cannot be answered in the framework of physics alone and one ends up doing metaphysics. Indeed, the recent crisis of M-theory- meant to be the final jewel in the crown of materialistic and reductionistic science- has led to the landscape problem, and many colleagues have given up the hope that ultimate theory could predict anything so that anthropic principle would be the only manner to connect theory with experiment.

3.2.2 Basic Philosophical Problems Of Quantum Mind Theories

At least the following problems could be seen as basic philosophical problems of quantum mind theories.

- What are the quantum correlates for consciousness? Entanglement has been proposed as a correlate of consciousness. For instance, in the orchestrated reduction approach of Hameroff and Penrose the period of consciousness ends with a state function reduction and quantum gravitation is believed to play a fundamental role in the understanding of consciousness. The believer in free will could see state function reduction or its generalization as as a natural quantum correlate for a moment of consciousness. The basic objection is that the randomness of state function reduction does not allow genuine goal directed free will. One could also argue that state function reduction generates entropy at least at the level of ensemble whereas intentional action should do just the opposite. Here one must however remember that entropy generation at the level of aspect need not mean entropy generation at the level of the member of ensemble.
- How the determinism of field equations and Schrödinger equation can be consistent with the non-determinism of the state function reduction? This question must be answered unless one is ready to give up the notion of objective reality completely or to believe in multiverse interpretation. These ways to circumvent the basic problem do not however leave much room for quantum consciousness theorizing. The closely related question about the relationship between experienced time and time of physicist has been already mentioned.
- What is the quantum correlate for the notion of self? The quantum notion of self should be a generalization of the notion of observer which in quantum measurement theory still remains a structureless outsider.
- What conscious information is? Can one give it a mathematical measure? Can one measure physically the amount of conscious information? Unfortunately the recent day physics can only provide measure for dis-information as Shannon entropy and the best that subsystem can achieve is no information at all if this picture is accepted.
- There is a bundle of questions about the quantum correlates of various aspects of conscious experience. For instance, what is the quantum correlate of mental image, and what are the quantum correlates of cognition, Boolean mind, sensory qualia, memory, and of emotions?
- An especially challenging question relates to the quantum correlate for the self referentiality of consciousness making possible reflective levels of consciousness. What it means physically to be conscious about what one is (or perhaps only "was") conscious? Jack Sarfatti was well aware about this problem and in his dualistic approach talked about feedback loop but still used a trick in which one divides various fields to matter-like and mind-like.

3.2.3 Basic Problems Of Quantum Biology And Quantum Neuroscience

The basic problems of quantum biology and neuroscience are closely related unless one is ready to believe that consciousness reduces to one particular function assignable to some particular part of brain ("consciousness module"). This kind of assignment can be imagined in engineerish neuroscience identifying brain as electric circuitry but does not have much sense in quantum mind approach.

The first list of first principle questions includes at least the following ones.

- What distinguishes between living and dead matter is certainly the fundamental question. In standard biology based on materialistic philosophy one tries to reduce the distinction to a list of properties which as such can be possessed by inanimate matter. Ability to replicate, to process information, to communicate, to form representations about the external world, the ability to self-organize to increasingly complex configurations, intentional behavior, ability to co-operate, could be properties of this kind. Up to self-organization the reduction seems plausible. It is easy to model self-organization (by say cell automatons) but it this dynamics is like the dynamics of traffic rules and neither classical nor quantum dynamics resembles it. Intentional behavior is impossible to understand in classical physics unless one claims that it is a mere illusion. This is the case also in quantum physics as we understand it since the randomness of the outcome of state function reduction seems to be in conflict with intentional behavior. Here one must however keep in mind that the individual subsystem performing a state function reduction could quite well experience it as an intentional action. In any case, standard view about state function reduction makes it difficult to co-operative behavior.
- What distinguishes between biochemistry and organic chemistry? For instance, how biomolecules can find themselves in the dense soup of biomolecules and how can one understand the effectiveness of bio-catalysts? One might think that these problems are well-understood since we have learned what happens in DNA replication, transcription, and translation and we know the complex reaction pathways. The dynamics involved is very much like the symbolic dynamics of society (one can predict the day of practicizing professional from knowing his profession but not from the knowledge of initial data of every possible elementary particle in his body). But what makes the soup of biomolecules a molecular society obeying a dynamics based on symbols? The description of biochemistry in terms of kinematics allows to construct complex reaction pathways based on the idea that each step of the reaction pathway requires a key which fits to a lock of a room containing a key to the lock to the next room [I90] but can one really deduce this kind of kinematics from standard quantum theory?
- Both biology and neuroscience characterizes subsystems of biological systems and brain in terms of functions they possess and one should also understand whether and how the quantum counterparts of functions emerge. The identification of various functions as time evolution of standard self-organization patterns is certainly a part of the answer. But what self-organization means? Conscious information is certainly the key notion but is the existing quantum theory able to characterize it?
- At the level of brain one of the key questions concerns EEG. Since EEG correlates strongly with the contents of consciousness it is difficult to believe that it is random side product of neural activity. What is then the real role of neuronal activity and EEG and its variants? Why EEG is needed? Signalling related to communication and control is what comes first in mind. But why this kind of signalling would be needed. Brain sends (receives) information but who receives (sends) it?
- How macroscopic quantum coherence is achieved allowing quantum super-positions in long time scales? How stable quantum entanglement is achieved? These are difficult problems if one wants to understand quantum mind without generalizing quantum theory itself. Planck constant is simply too small so that dissipation rates are too high and coherence times and lengths are too short. Should physicists adopt a humbler attitude and consider seriously the possibility that the existing physics is not enough and try to learn from biology instead of saying that living systems are just complex?

3.2.4 Could Anomalies Help?

Anomalies are the best way to end up with a discovery of something new. Of course, living matter as such is a gigantic anomaly but this does not help much. One should pick up the anomalies which are in sharp conflict with the existing physics and give a clear hint about what is wrong with our cherished assumptions.

• In quantum mind approach EEG should be a quantal phenomenon since it correlates with consciousness. From the basic formula E = hf of quantum mechanics the energies of EEG photons are however ridiculously small as compared to the thermal energy at physiological temperatures. The strange quantal looking effects of ELF photons on vertebrate (why just vertebrate?!) brain at frequencies which correspond to cyclotron frequencies of biologically important ions such as Ca⁺⁺ are however an experimental fact (see for instance [J23]). The effects of magnetic field patterns on brain studied by Persinger and collaborators represent also an example of this kind of strange effects [J86]. The strange findings about the behavior of cell membrane [I82] suggest that ionic currents do not dissipate much. The recently discovered burning of water when irradiated by radio wave photons [D18, D1] suggests that energetically these photons behave like photons of visible light. The recent findings about photosynthesis [I25] suggest quantum coherence in cellular length scale.

Is standard quantum theory able to explain these findings? Should one challenge the belief that Planck constant is just a conversion factor between units which can be put equal one with a suitable choice of units? Could Planck constant have a spectrum of discrete values? This would explain the strange findings since by E = hf relation low frequencies could correspond to high energies and dissipation rates -in the first guess inversely proportional to \hbar - could be very small. Large values of Planck constant would also increase the spatial and time scales of quantum coherence and might solve the basic technical problem of quantum consciousness theories.

- Also bio-photons [I63] correlate with the state of living system but are poorly understood in the existing theoretical framework.
- Libet's findings about strange time delays associated with the passive aspects of consciousness serve also as a hint. Our sensory data has age which is a fraction of second and corresponds to a photon wavelength $\lambda = cT$ to a length scale, which is of order of Earth size. As if sensory data would be communicated somewhere. Where?
- Cyclotron frequencies of biologically important ions in a magnetic field.2 Gauss (smaller than the nominal value of 5 Gauss of the Earth's magnetic field) are involved with the effects of ELF radiation on vertebrate brain. Also Schumann resonances are reported to have effects on brain. Are some kind of magnetic field structures involved? Earth's magnetic field and perhaps also the magnetic field patterns associated with biological system itself with $B = 2B_E/5$ for one important level in the hierarchy? As noticed in [J95], the cyclotron energy scale of electron in pT range is in EEG range and pT range indeed characterizes the magnetic field associated with brain activity. Do also these magnetic structures carry Cooper pairs of electrons?
- ADP-ATP machinery is the core of energy metabolism and its description involves the problematic notion of high energy phosphate bond [I15]. Does this notion really reduce to standard quantum theory?
- The chiral selection of biomolecules in living matter [I8, I135] means a large parity breaking. This is a complete mystery in standard model which predicts extremely small parity breaking effects. Therefore chiral selection is extremely valuable anomaly helping to guess what kind of new physics might be involved with living matter. Somehow it seems that the parity breaking effects which are large in electro-weak scale appear in immensely zoomed up scales (scaling factors of order 10¹⁰ would be involved)

3.3 Some Aspects Of Quantum TGD

In the following I summarize very briefly those basic notions of TGD which are especially relevant for TGD inspired consciousness theory and quantum biology. The representation will be practically formula free. The article series published in Prespace-time Journal [L9, L10, L13, L14, L11, L8, L12, L15] describes the mathematical theory behind TGD. The seven books about TGD [K141, K133, K30, K86, K89, K107, K121] provide a detailed summary about the recent state of TGD.

3.3.1 New Space-Time Concept

The physical motivation for TGD was what I have christened the energy problem of General Relativity. The notion of energy is ill-defined because the basic symmetries of empty space-time are lost in the presence of gravity. The way out is based on assumption that space-times are imbeddable as 4-surfaces to certain 8-dimensional space by replacing the points of 4-D empty Minkowski space with 4-D very small internal space. This space -call it S- is unique from the requirement that the theory has the symmetries of standard model: $S = CP_2$, where CP_2 is complex projective space with 4 real dimensions [L15], is the unique choice.

The replacement of the abstract manifold geometry of general relativity with the geometry of surfaces brings the shape of surface as seen from the perspective of 8-D space-time and this means additional degrees of freedom giving excellent hopes of realizing the dream of Einstein about geometrization of fundamental interactions.

The work with the generic solutions of the field equations assignable to almost any general coordinate invariant variational principle led soon to the realization that the space-time in this framework is much more richer than in general relativity.

- 1. Space-time decomposes into space-time sheets with finite size: this lead to the identification of physical objects that we perceive around us as space-time sheets. For instance, the outer boundary of the table is where that particular space-time sheet ends. Besides sheets also string like objects and elementary particle like objects appear so that TGD can be regarded also as a generalization of string models obtained by replacing strings with 3-D surfaces.
- 2. Elementary particles are identified as topological inhomogenuities glued to these space-time sheets. In this conceptual framework material structures and shapes are not due to some mysterious substance in slightly curved space-time but reduce to space-time topology just as energy- momentum currents reduce to space-time curvature in general relativity.
- 3. Also the view about classical fields changes. One can assign to each material system a field identity since electromagnetic and other fields decompose to topological field quanta. Examples are magnetic and electric flux tubes and flux sheets and topological light rays representing light propagating along tube like structure without dispersion and dissipation making em ideal tool for communications [K91]. One can speak about field body or magnetic body of the system.

Field body indeed becomes the key notion distinguishing TGD inspired model of quantum biology from competitors. The magnetic body inherits from the biological body an onion-like fractal structure. Each part of the magnetic body can be seen as an intentional agent using the corresponding part of the biological body as a motor instrument and sensory receptor. The size scale of the magnetic body is in general much larger than that of biological body. Cyclotron frequency identified as frequency of photons able to exist as oscillations at magnetic body gives an estimate for the size of the magnetic body corresponding to a particular magnetic field strength. For 10 Hz frequency the size scale is of order Earth size. In this framework a fractal generalization of EEG and its variants provides a communication and control tool for magnetic body. The findings of Libet about time delays associated with the passive aspects and meaning that sensory data is a fraction of second old [J42] could be understood as delays due to the finite velocity of light: it takes finite time for the signal to propagate from biological body to the magnetic body.

This obviously means a profound modification of the views about what we are. The identification with the biological body could be understood as an illusion: a child looking a movie assimilates completely with the hero. There is a rich variety of illusions related to this identification of observer with the region of space from which the dominating contribution to consciousness comes from.

3.3.2 Zero Energy Ontology

In standard ontology of quantum physics physical states are assumed to have positive energy. In zero energy ontology physical states decompose to pairs of positive and negative energy states such that all net values of the conserved quantum numbers vanish. The interpretation of these states in ordinary ontology would be as transitions between initial and final states, physical events. By quantum classical correspondences zero energy states must have space-time and embedding space correlates.

- 1. Positive and negative energy parts reside at future and past light-like boundaries of causal diamond (CD) defined as intersection of future and past directed light-cones and visualizable as double cone. The analog of CD in cosmology is big bang followed by big crunch. CDs for a fractal hierarchy containing CDs within CDs. Disjoint CDs are possible and CDs can also intersect.
- 2. p-Adic length scale hypothesis [?] otivates the hypothesis that the temporal distances between the tips of the intersecting light-cones come as octaves $T = 2^n T_0$ of a fundamental time scale T_0 defined by CP_2 size R as $T_0 = R/c$. One prediction is that in the case of electron this time scale is 1 seconds defining the fundamental biorhythm. Also in the case u and d quarks the time scales correspond to biologically important time scales given by 10 ms for u quark and by and 2.5 ms for d quark [K17]. This means a direct coupling between microscopic and macroscopic scales.

Zero energy ontology conforms with the crossing symmetry of quantum field theories meaning that the final states of the quantum scattering event are effectively negative energy states. As long as one can restrict the consideration to either positive or negative energy part of the state ZEO is consistent with positive energy ontology. This is the case when the observer characterized by a particular CD studies the physics in the time scale of much larger CD containing observer's CD as a sub-CD. When the time scale sub-CD of the studied system is much shorter that the time scale of sub-CD characterizing the observer, the interpretation of states associated with sub-CD is in terms of quantum fluctuations.

ZEO solves the problem of initial state since in principle any zero energy state is obtained from any other state by a sequence of quantum jumps without breaking of conservation laws. The fact that energy is not conserved in general relativity based cosmologies can be also understood since each CD is characterized by its own conserved quantities. As a matter fact, one must be speak about average values of conserved quantities since one can have a quantum superposition of zero energy states with the quantum numbers of the positive energy part varying over some range.

For thermodynamical states this is indeed the case and this leads to the idea that quantum theory in ZEO can be regarded as a "complex square root" of thermodynamics obtained as a product of positive diagonal square root of density matrix and unitary S-matrix. M-matrix defines time-like entanglement coefficients between positive and negative energy parts of the zero energy state and replaces S-matrix as the fundamental observable. In standard quantum measurement theory this time-like entanglement would be reduced in quantum measurement and regenerated in the next quantum jump if one accepts Negentropy Maximization Principle (NMP) [K80] as the fundamental variational principle. Various M-matrices define the rows of the unitary U matrix characterizing the unitary process part of quantum jump. From the point of view of consciousness theory the importance of ZEO is that conservation laws in principle pose no restrictions for the new realities created in quantum jumps: free will is maximal.

3.3.3 The Hierarchy Of Planck Constants

The motivations for the hierarchy of Planck constants come from both astrophysics and biology. The biological motivations have been already discussed. In astrophysics the observation of Nottale [E1] that planetary orbits in solar system seem to correspond to Bohr orbits with a gigantic gravitational Planck constant motivated the proposal that Planck constant might not be constant after all [K117, K93].

This led to the introduction of the quantization of Planck constant as an independent postulate. It has however turned that quantized Planck constant in effective sense could emerge from the basic structure of TGD alone. Canonical momentum densities and time derivatives of the embedding space coordinates are the field theory analogs of momenta and velocities in classical mechanics. The extreme non-linearity and vacuum degeneracy of Kähler action imply that the correspondence between canonical momentum densities and time derivatives of the embedding space coordinates is 1-to-many: for vacuum extremals themselves 1-to-infinite.

A convenient technical manner to treat the situation is to replace embedding space with its n-fold singular covering. Canonical momentum densities to which conserved quantities are proportional would be same at the sheets corresponding to different values of the time derivatives. At each sheet of the covering Planck constant is effectively $\hbar = n\hbar_0$. This splitting to multi-sheeted structure can be seen as a phase transition reducing the densities of various charges by factor 1/nand making it possible to have perturbative phase at each sheet (gauge coupling strengths are proportional to $1/\hbar$ and scaled down by 1/n). The connection with fractional quantum Hall effect [D2] is almost obvious. At the more detailed level one finds that the spectrum of Planck constants would be given by $\hbar = n_a n_b \hbar_0$.

This has many profound implications, which are wellcome from Quantum Mind perspective.

- 1. Quantum coherence and quantum superposition become possible in arbitrary long length scales. One can speak about zoomed up variants of elementary particles and zoomed up sizes make it possible to satisfy the overlap condition for quantum length parameters used as a criterion for the presence of macroscopic quantum phases. In the case of quantum gravitation the length scale involved are astrophysical. This would conform with Penrose's intuition that quantum gravity is fundamental for the understanding of consciousness and also with the idea that consciousness cannot be localized to brain.
- 2. Photons with given frequency can in principle have arbitrarily high energies by E = hf formula, and this would explain the strange anomalies associated with the interaction of ELF em fields with living matter [J23]. Quite generally the cyclotron frequencies which correspond to energies much below the thermal energy for ordinary value of Planck constant could correspond to energies above thermal threshold.
- 3. The value of Planck constant is a natural characterizer of the evolutionary level and biological evolution would mean a gradual increase of the largest Planck constant in the hierarchy characterizing given quantum system. Evolutionary leaps would have interpretation as phase transitions increasing the maximal value of Planck constant for evolving species. The space-time correlate would be the increase of both the number and the size of the sheets of the covering associated with the system so that its complexity would increase.
- 4. The phase transitions changing Planck constant change also the length of the magnetic flux tubes. The natural conjecture is that biomolecules form a kind of Indra's net connected by the flux tubes and ħ changing phase transitions are at the core of the quantum bio-dynamics. The contraction of the magnetic flux tube connecting distant biomolecules would force them near to each other making possible for the bio-catalysis to proceed. This mechanism could be central for DNA replication and other basic biological processes. Magnetic Indra's net could be also responsible for the contractions and expansions of the intracellular gel phase. The reconnection of flux tubes would allow the restructuring of the signal pathways between biomolecules and other subsystems and would be also involved with ADP-ATP transformation inducing a transfer of negentropic entanglement [?] (see Fig. http://tgdtheory.fi/appfigures/cat.jpg or Fig. ?? in the appendix of this book). The braiding of the magnetic flux tubes could make possible topological quantum computation like processes and analog of computer memory realized in terms of braiding patterns [K6].
- 5. p-Adic length scale hypothesis and hierarchy of Planck constants suggest entire hierarchy of zoomed up copies of standard model physics with range of weak interactions and color forces

scaling like \hbar . This is not conflict with the known physics for the simple reason that we know very little about dark matter (partly because we might be making misleading assumptions about its nature).

Dark matter would make possible the large parity breaking effects manifested as chiral selection of bio-molecules [I8]. What is required is that classical Z^0 and W fields responsible for parity breaking effects are present in cellular length scale. If the value of Planck constant is so large that weak scale is some biological length scale, weak fields are effectively massless below this scale and large parity breaking effects become possible.

For the solutions of field equations which are almost vacuum extremals Z^0 field is nonvanishing and proportional to electromagnetic field. The hypothesis that cell membrane corresponds to a space-time sheet near a vacuum extremal (this corresponds to criticality very natural if the cell membrane is to serve as an ideal sensory receptor) leads to a rather successful model for cell membrane as sensory receptor with lipids representing the pixels of sensory qualia chart. The surprising prediction is that bio-photons [I63] and bundles of EEG photons can be identified as different decay products of dark photons with energies of visible photons. Also the peak frequencies of sensitivity for photoreceptors are predicted correctly [K103].

3.3.4 P-Adic Physics And Number Theoretic Universality

p-Adic physics [K126, K86] has become gradually a key piece of TGD inspired biophysics. Basic quantitative predictions relate to p-adic length scale hypothesis and to the notion of number theoretic entropy. Basic ontological ideas are that life resides in the intersection of real and p-adic worlds and that p-adic space-time sheets serve as correlates for cognition.

p-Adic number fields

p-Adic number fields Q_p [A13] -one for each prime p- are analogous to reals in the sense that one can speak about p-adic continuum and that also p-adic numbers are obtained as completions of the field of rational numbers. One can say that rational numbers belong to the intersection of real and p-adic numbers. p-Adic number field Q_p allows also an infinite number of its algebraic extensions. Also transcendental extensions are possible. For reals the only extension is complex numbers.

p-Adic topology defining the notions of nearness and continuity differs dramatically from the real topology. An integer which is infinite as a real number can be completely well defined and finite as a p-adic number. In particular, powers p^n of prime p have p-adic norm (magnitude) equal to p^{-n} in Q_p so that at the limit of very large n real magnitude becomes infinite and p-adic magnitude vanishes.

p-Adic topology is rough since p-adic distance d(x, y) = d(x-y) depends on the lowest pinary digit of x-y only and is analogous to the distance between real points when approximated by taking into account only the lowest digit in the decimal expansion of x - y. A possible interpretation is in terms of a finite measurement resolution and resolution of sensory perception. p-Adic topology looks somewhat strange. For instance, p-adic spherical surface is not infinitely thin but has a finite thickness and p-adic surfaces possess no boundary in the topological sense. Ultra-metricity is the technical term characterizing the basic properties of p-adic topology and is coded by the inequality $d(x-y) \leq Min\{d(x), d(y)\}$. p-Adic topology brings in mind the decomposition of perceptive field to objects.

Physical and biological motivations for p-adic number fields

The physical motivations for p-adic physics came from the observation that p-adic thermodynamics -not for energy but infinitesimal scaling generator of so called super-conformal algebra [A2] acting as symmetries of quantum TGD [K133] - predicts elementary particle mass scales and also masses correctly under very general assumptions [K86]. In particular, the ratio of proton mass to Planck mass, the basic mystery number of physics, is predicted correctly. The basic assumption is that the preferred primes characterizing the p-adic number fields involved are near powers of two: $p \simeq 2^k$, k positive integer. Those nearest to power of two correspond to Mersenne primes $M_n = 2^n - 1$. One can also consider complex primes known as Gaussian primes, in particular Gaussian Mersennes $M_{G,n} = (1+i)^n - 1.$

It turns out that Mersennes and Gaussian Mersennes are in a preferred position physically in TGD based world order. What is especially interesting is that the p-adic length scale range 10 nm-5 μ m contains as many as four scaled up electron Compton lengths $L_e(k) = \sqrt{5}L(k)$ assignable to Gaussian Mersennes $M_k = (1+i)^k - 1$, k = 151, 157, 163, 167 [K103]. This number theoretical miracle supports the view that p-adic physics is especially important for the understanding of living matter.

p-Adic length scale hypothesis suggests the identification of metabolic energy currencies as energy quanta liberated as particle drops from space-time sheet to a larger one. These energy quanta correspond to increments of zero point kinetic energy. Metabolic energy currencies would be completely universal and exist already during the prebiotic era so that metabolic machinery would build up around this pre-existing structure. A simple (and also rough) model based on p-adic length scale hypothesis allows to estimate the increments of zero point kinetic energy. The quantum corresponding to about 5 eV has place in this hierarchy for which basic energies (those for which larger space-time sheet is very large) come as octaves of basic energy quantum [K17, K68]. These energy quanta do not have interpretation in terms of molecular transitions and there exist anomalous lines of radiation from interstellar space both in IR, visible, and UV region [K17].

Life as something in the intersection of real and p-adic worlds

The philosophical for p-adic numbers fields come from the question about the possible physical correlates of cognition [K88]. Cognition forms representations of the external world which have finite cognitive resolution and the decomposition of the perceptive field to objects is an essential element of these representations. Therefore p-adic space-time sheets could be seen as candidates of thought bubbles, the mind stuff of Descartes.

Rational numbers belong to the intersection of real and p-adic continua. An obvious generalization of this statement applies to real manifolds and their p-adic variants. When extensions of p-adic numbers are allowed, also some algebraic numbers can belong to the intersection of p-adic and real worlds. The notion of intersection of real and p-adic worlds has actually two meanings.

- 1. The intersection could consist of the rational and possibly some algebraic points in the intersection of real and p-adic partonic 2-surfaces at the ends of CD. This set is in general discrete. The interpretation could be as discrete cognitive representations.
- 2. The intersection could also have a more abstract meaning. For instance, the surfaces defined by rational functions with rational coefficients have a well-defined meaning in both real and p-adic context and could be interpreted as belonging to this intersection. There is strong temptation to assume that intentions are transformed to actions only in this intersection. One could say that life resides in the intersection of real and p-adic worlds in this abstract sense.

Additional support for the idea comes from the observation that Shannon entropy $S = -\sum p_n log(p_n)$ allows a p-adic generalization if the probabilities are rational numbers by replacing $log(p_n)$ with $-log(|p_n|_p)$, where $|x|_p$ is p-adic norm. Also algebraic numbers in some extension of p-adic numbers can be allowed. The unexpected property of the number theoretic Shannon entropy is that it can be negative and its unique minimum value as a function of the p-adic prime p it is always negative. Entropy transforms to information!

In the case of number theoretic entanglement entropy there is a natural interpretation for this. Number theoretic entanglement entropy would measure the information carried by the entanglement whereas ordinary entanglement entropy would characterize the uncertainty about the state of either entangled system. For instance, for p maximally entangled states both ordinary entanglement entropy and number theoretic entanglement negentropy are maximal with respect to R_p norm. Entanglement carries maximal information. The information would be about the relationship between the systems, a rule. Schrödinger cat would be dead enough to know that it is better to not open the bottle completely.

Negentropy Maximization Principle [K80] coding the basic rules of quantum measurement theory implies that negentropic entanglement can be stable against the effects of quantum jumps unlike entropic entanglement. Therefore living matter could be distinguished from inanimate matter also by negentropic entanglement possible in the intersection of real and p-adic worlds. In consciousness theory negentropic entanglement could be seen as a correlate for the experience of understanding or any other positively colored experience, say love.

Negentropically entangled states are stable but binding energy and effective loss of relative translational degrees of freedom is not responsible for the stability. Therefore bound states are not in question. The distinction between negentropic and bound state entanglement could be compared to the difference between unhappy and happy marriage. The first one is a social jail but in the latter case both parties are free to leave but do not want to. The special characterics of negentropic entanglement raise the question whether the problematic notion of high energy phosphate bond citebbioHEP central for metabolism could be understood in terms of negentropic entanglement. This would also allow an information theoretic interpretation of metabolism since the transfer of metabolic energy would mean a transfer of negentropy [?].

3.4 Consciousness Theory As Extension Of Quantum Measurement Theory

TGD inspired theory of consciousness [K76] could be seen as a generalization of quantum measurement theory. The notions of quantum jump and self self are the key notions. Negentropy Maximization Principle (NMP) [K80] is the basic dynamical principle. NMP is mirror image for the second law of thermodynamics and states that the amount of conscious information gain in quantum jump is maximal. NMP reproduces standard quantum measurement theory for entropic entanglement and is in this case consistent with the second law since the non-determinism of state function reductions implies the increase of ensemble entropy.

3.4.1 Quantum Jumps As Moment Of Consciousness

The starting point of TGD inspired theory of consciousness was the identification of quantum jump as a moment of consciousness [K76].

1. Quantum jump has a complex anatomy which however simplifies in ZEO. Quantum jump involves unitary time evolution leading from a state resulting in state function reduction to a quantum superposition of states: one could speak of multiverse. This step is described by the counterpart of the unitary process of Penrose and is coded by a unitary matrix U in the state space formed by zero energy states. U is therefore not identifiable directly as S-matrix of quantum field theories but contains as its rows all possible M-matrices which are what particle physicist tries to measure in laboratory. State function reduction and state preparation can be assigned to the opposite light-like boundaries of CD.

A good metaphor is Djinn in the bottle. In U-process bottle is opened and Djinn comes out and creates a quantum superposition of all possible worlds. The wish of the observer is fulfilled and leads to a state function reduction. Actually there is an entire cascade of state function reductions starting from the level of the entire universe which splits the entangleement subsystems already obtained in a step-wise manner to pairs un-entangled sub-systems. The splitting for a given sub-system occurs only if it is consisent with NMP.

For the ordinary definition of entanglement entropy the process would lead to a completely unentangled situation. If the number theoretic entanglement entropy making sense for rational (and even algebraic) entanglement probabilities is allowed, the process stops unless the reduction of entanglement reduces the entanglement entropy. Therefore the number theoretic entanglement possible in the intersection of real and p-adic worlds can be stable and living systems are able to preserve their coherence.

2. Since the reduction cascade proceeds from top to bottom, one can speak about fractal formed by quantum jumps within quantum jumps. One cannot assign to the steps of this sequence any duration of geometric time. One can however associate to it an experienced duration and it is very tempting to assume that the experienced duration increases as one climbs up in the self hierarchy. 3. Quantum jump replaces the quantum superposition of classical histories (space-time surfaces, classical worlds) with a new one whereas ordinary state function reduction would do this for time=constant snapshot of Schrödinger evolution. Quantum jump does not spoil the determinism of classical dynamics or of Dirac equation since it occurs entirely outside space-time and Hilbert space. In quantum jump both the geometric future and past (defined only within measurement resolution) are replaced with new ones. The mysterious finding of Libet [J15] that intentional action is preceded by neural activity can be interpreted in this framework without giving up the notion of free will. This raises a fascinating question about time scales in which the geometric past can be affected in quantum jump. Also memories stored in the geometric past can be affected in quantum jumps and the fact that memories are highly unstable suggest that the time scale is measured in years.

It must be added that the notion of classical determinism in its standard form fails due to the special properties of Kähler action (vacuum degeneracy mathematically analogous to a gauge degeneracy but physically analogous to 4-D spin glass degeneracy). This failure provides a space-time correlate for the non-determinism of the quantum jump sequence.

3.4.2 The Notion Of Self

The notion of self can be seen as a generalization of the notion of observer. The original definition of self was as a subsystem able to remain unentangled under state function reductions associated with subsequent quantum jumps. Everything is consciousness but consciousness can be lost if self develops bound state entanglement during U process so that state function reduction to smaller un-entangled pieces is impossible. A second aspect of self was assumed to be the integration of subsequent quantum jumps to coherent whole giving rise to the experienced flow of time.

What is the precise identification of self allowing to understand both of these aspects turned out to be difficult problem. I became aware the solution of the problem in terms of zero energy ontology (ZEO) only quite recently (2014). Self indeed corresponds to a sequence of quantum jumps integrating to single unit, but these quantum jumps correspond to state function reductions to a fixed boundary of causal diamond CD leaving the corresponding parts of zero energy states invariant. The parts of zero energy states at second boundary of CD change even the position of opposite boundary changes: one actually has wave function over positions of second boundary (CD sizes roughly) and this wave function changes. In positive energy ontology these repeated state function reductions would have no effect on the state but in TGD framework there occurs a change for the second boundary and gives rise to the experienced flow of time and its arrow and gives rise to self. The first quantum jump to the opposite boundary corresponds to the act of free will or wake-up of self. Hence act of free will means change of the arrow of psychological time at some level of hierarchy of CDs.

This allows to understand the relationship between subject and geometric time and how the arrow of and flow of psychological time emerges. The average distance between the tips of CD increases on the average as along as state function functions occur repeatedly at the fixed boundary: situation is analogous to that in diffusion. The localization of contents of conscious experience to boundary of CD gives rise to the illusion that universe is 3-dimensional. The possibility of memories made possibly by hierarchy of CDs demonstrates that this is not the case. Self is simply the sequence of state function reductions at same boundary of CD remaining fixed and the lifetime of self is the total growth of the average temporal distance between the tips of CD.

There exists an infinite hierarchy of number theoretical entropies [K80] making sense for rational or even algebraic entanglement probabilities. In this case the entanglement negentropy can be negative so that Negentropy Maximization principle (NMP) favors generation of negentropic entanglement, which need not be bound state entanglement in standard sense.

In the case of negentropic entanglement (see Fig. http://tgdtheory.fi/appfigures/cat.jpg or Fig. ?? in the appendix of this book) a more natural interpretation is that expansion of consciousness rather than loss of it is experienced as self entangles with second system negentropically. Only entropic entanglement would lead to a loss of consciousness. Second condition would be that self is stable against splitting to unentangled subsystems. This criterion is satisfied if self corresponds to a system for which the entanglement between its subsystems is negentropic.

This leads to the vision that negentropic entanglement defines kind of Akashic records, kind of library storing conscious or potentially conscious information. According to the recent view, Akashic records could define self as opposed to self model defined in terms of memory representations relying on bits. Consistency with standard quantum measurement theory [K80] requires that density matrix for negentropic entanglement is proportional to unit matrix associated to unitary entanglement matrix associated with quantum computation. "Akashic records" would define self and would be consciously experienced.

Self experiences its sub-selves as mental images and even we would represent mental images of some higher collective self. Everything would be conscious but consciousness could be only lost. The flow of consciousness for a given self could be due to the quantum jump sequences performed by its sub-selves giving rise to mental images.

By quantum classical correspondence self has also space-time correlates. One can visualize sub-self as a space-time sheet "glued" by topological sum to the space-time sheet of self. Subsystem is not described as a tensor factor as in the standard description of subsystems. Also sub-selves of selves can entangle negentropically and this gives rise to a sharing of mental images about which stereo vision would be basic example. Quite generally, one could speak of stereo consciousness. Also the experiences of sensed presence [J95] could be understood as a sharing of mental images between brain hemispheres which are not themselves entangled. This is possible also between different brains. In the normal situation brain hemispheres are entangled.

At the level of 8-dimensional embedding space the natural correlate of self would be CD (causal diamond). At the level of space-time the correlate would be space-time sheet or light-like 3-surface. The contents of consciousness of self would be determined by the space-time sheets in the interior of CD. Without further restrictions the experience of self would be essentially fourdimensional. Memories would be like sensory experiences except that they would be about the geometric past and for some reason are not usually colored by sensory qualia. As already noticed, .1 second time scale defining the duration of moment for sensory experience corresponds to that of electron's CD which suggests that Cooper pairs of electrons are essential for the sensory qualia.

3.4.3 How Experienced Time And The Geometric Time Of Physicist Relate To Each Other?

The relationship between experienced time and time of physicist is one of the basic puzzles of modern physics. In the proposed framework they are certainly two different things and the challenge is to understand why the correlation between them is so strong that it has led to their identification. One can imagine several alternative views explaining this correlation [K139, ?, K13] and it is better to keep mind open.

Basic questions

The flow of subjective time corresponds to quantum jump sequences for sub-selves of self having interpretation as mental images. If mind is completely empty of mental images subjectively experienced time ceases to exists. This leaves however several questions to be answered.

- 1. Why the contents of conscious of self comes from a finite space-time region looks like an easy question. If the contents of consciousness for sub-selves representing mental images is localized to the sub-CDs with indeed have defined temporal position inside CD assigned with the self the contents of consciousness is indeed from a finite space-time volume. This implies a new view about memory. There is no need to store again and again memories to the "brain now" since the communications with the geometric past by negative energy signals and also time-like negentropic quantum entanglement allow the sharing of the mental images of the geometric past.
- 2. There are also more difficult questions. Subjective time has arrow and has only the recent and possibly also past. The subjective past could in principle reduce to subjective now if conscious experience is about 4-D space-time region so that memories would be always geometric memories. How these properties of subjective time are transferred to apparent properties of geometric time? How the arrow of geometric time is induced? How it is possible that the locus for the contents of conscious experience shifts or at least seems to be shifted quantum jump by quantum jump to the direction of geometric future? Why the sensory mental images are located in a narrow time interval of about .1 seconds in the usual states

of consciousness (not that sensory memories are possible: scent memories and phantom pain in leg could be seen as examples of vivid sensory memory)?

The recent view about arrow of time

The basic intuitive idea about the explanation for the arrow of psychological time has been the same from the beginning - diffusion inside light-cone - but its detailed realization has required understanding of what quantum TGD really is. The replacement of ordinary positive energy ontology with zero energy ontology (ZEO) has played a crucial role in this development. The TGD based vision about how the arrow of geometric time is by no means fully developed and final. It however seems that the most essential aspects have been understood now.

- 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 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 or only correlate with it?
- 2. The state function reductions can occur both 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!

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.

- 3. This approach codes also the arrow of time at the space-time level: the average spacetime 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.
- 4. In principle the arrow of time can temporarily change but it would seem that this can occur in very special circumstances and probably takes place in 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.

3.4.4 Quantum Correlates For Various Aspects Of Conscious Experience

The identification of quantum correlates of cognition and intentionality, of sensory qualia, Boolean mind, and of emotions [K59] represents one challenge for Quantum Mind theories. As already explained, p-adic physics, the vision about life as something residing in the intersection of real and p-adic worlds, and the notion of number theoretic entropy provide a plausible starting point when one tries to say something about the geometric and quantum correlates of cognition and intentionality. Zero energy ontology makes possible the transitions transforming p-adic zero energy states to their real counterparts and having interpretation in terms of intentional action.

- 1. Quantum numbers characterize quantum states. Therefore the increments ΔQ of quantum numbers for a subsystem should characterize quantum jumps and it is attractive to assign classify fundamental qualia in terms of quantum number increments. "The increments of quantum numbers for a sub-system representing self" looks innocent but what it really means is surprisingly difficult to make precise. The following attempt relies on ZEO.
 - (a) For the positive energy part of state located at "lower" boundary of CD self subsystem S and environment E are un-entangled. At the "upper" boundary there is entanglement between S and E, and it should be able to assign qualia as quantum number increments to this entanglement.
 - (b) Consider increments of color quantum numbers identified in terms of visual colors as an example. In the positive energy state color quantum numbers for an unentangled subsystem S vanish by color confinement. In negative energy state they can be nonvanishing for S but vanish for $S \otimes E$. The experienced qualia for S are determined as quantum averages of color quantum numbers in the entangled state and expressible in terms of the sub-system density matrix. One can indeed assign to the zero energy state increments ΔQ_{ZEO} of color quantum numbers as difference of color quantum numbers for S at "upper" and "lower" boundaries of C. These increments characterize zero energy state rather than quantum jump.
 - (c) In state function reduction the entanglement at upper boundary is reduced if the entanglement is entropic whereas negentropic entanglement can be stable. Quale is experienced sensorily as long as quantum jumps preserve negentropic entanglement. When entanglement is eventually reduced, the experience can be only a memory about the experienced quale. The increments ΔQ of color quantum numbers in quantum jump can be identified as $\Delta Q = \Delta Q_{ZEO}$. Hence this notion is indeed well-defined.
 - (d) This interpretation allows to assign to the quantum jump also space-time evolution changing the quantum numbers in the same manner as they change in quantum jump. This is what quantum-classical correspondence indeed requires.

One application is the identification of basic colors in terms of color quantum number increments of quantum states [K59]. This identification makes sense if one accepts the fractal hierarchy of QCD like dynamics allowed by p-adic length scale hierarchy and by the hierarchy of Planck constants. The original concrete model was provided by the capacitor model of sensory qualia in which a large number of particles which same quantum numbers flows to a subsystem during quantum jump inducing the analog of di-electric breakdown (note the analogy with nerve pulse). Bose-Einstein condensation provides one possible realization. In this case one can say that the quantum numbers of the particle in question represent the basic quale which is amplified.

The above picture forces to modify this view by replacing a color capacitor with a fixed size with that of a variable size corresponding to the size of system S and $S \otimes E$: the second plate of capacitor either in S or environment. The flow of charges associated with the transition generating quale still makes sense and generates strong color polarization in the scale $S \otimes E$. In the model the increase of the size of the color capacitor means a formation of flux tubes between the sensory receptor and environment such that net color is non-vanishing only for these flux tubes. In state function reduction reducing entanglement the flux tubes are split and S become color neutral but can represent a memory about the quale as negentropic color neutral entanglement in the scale of S: some sub-system of S can now experience the color quale. This suggests a holographic memory in which quale eventually is represented in very small scale in terms of negentropic entanglement.

The argument involves assumption about color confinement. In the case of qualia assignable to electromagnetic charges, spin, etc... similar assumption makes sense. Even in case of momentum and angular momentum this assumption makes sense and means that subsystem in the state of experiencing momentum or angular momentum increment as quale is in a real accelerated motion in the scale of CD. As a matter fact, the vanishing of quantum numbers of S in absence of entanglement might not be necessary for the interpretation.

2. One could also speak about Boolean qualia and fermions provide possible correlates for them. The 2^N many-fermion states of fermionic Fock space for N fermionic qubits define a basis of Boolean algebra. The entangled pairs of fermionic states associated with the positive and negative energy parts of zero energy states define quantal Boolean functions as sums over entangled pairs of many fermion states. Negentropic entanglement could define a representation of a rule with entangled pairs representing various instances of the rule. Time-like entanglement would define a representation for a "law of physics" and *M*-matrices would be fundamental representations of this kind. The increments of the fermionic quantum numbers could define Boolean qualia and one can imagine Boolean capacitor mechanism allowing to amplify a given Boolean statement.

One should be also able to say something about the quantum correlates of emotions. Here the notion of negentropic entanglement might be the key concept.

1. Emotions have a quale like character. For instance, psychological pleasure and pain resemble their physiological counterparts- and quite generally there is a tendency to assign to emotions the attributes of sensory experience. It would be attractive to assign this positive/negative dichotomy to the increase/reduction of entanglement negentropy. Emotion would represent Boolean bit as the sign of negentropy increment. The destruction of generation of negentropic entanglement would therefore be the core element of emotional quale. The character of entanglement involved would determine whether the emotion corresponds to pleasure or pain, joy or sorrow, pride or shame.

In the case of physiological pain or pleasure it is easy to imagine that the cause of pain destroys/creates negentropic entanglement. Pain and pleasure at this level relates directly to what happens to metabolism. This is easy to understand if the basic function of energy metabolism is to transfer negentropic entanglement. For higher level emotions the negentropy reduction or increase could be produced artificially to give an emotional content for something regarded as important.

- 2. Very often emotions are characterized by good-bad/right-wrong dichotomy characterizable by single binary digit. Perhaps emotions provide a representation of a high level summary about large amounts information, a kind of Boolean function of very many qubits. The function of neural transmitters can be often interpreted in terms of reward or punishment. Information and emotions seem to be closely related: peptides are often regarded as both information molecules and molecules of emotion [J22]. This can be understood if the function of information molecule is to induce emotional response representing the information.
- 3. Comparison to a standard -be it moral rule, expected or desired behavior, or something elseis rather often an essential aspect of emotion. Comparison can in principle be represented as a quantal Boolean function involving the standard (say moral rule) represented in terms of negentropic entanglement. If the Boolean instance compared with the rule corresponds to an instance allowed by the rule, positive emotion results. Otherwise the emotion is negatively colored. One might also think that there is expectation for the result of comparison. If the outcome differs from expected- which corresponds to a flip of bit, positive or negative emotion results but could do so as a secondary representation. The above argument suggests that the outcome of comparison does not represent the emotion as such but there is a neural circuitry encoding the outcome to reward or punishment.

3.4.5 Self Referentiality Of Conscious Experience

Self referentiality of consciousness is one of its most mysterious looking aspects. In a loose formulation one could say that system is able to be conscious what it *is* conscious of. This formulation however leads to an infinite hierarchy of reflective levels and therefore to a paradox. One can however milden the formulation by saying that self-referential system is able to be conscious about what it *was* conscious of (with respect to subjective time of course!)

In this formulation quantum classical correspondence gives hopes about the understanding of self-referentiality. Quantum classical correspondence means in TGD framework that not only quantum states but also quantum jump sequences have space-time correlates. The failure of classical determinism for Kähler action in standard sense of the word is responsible for this and relates directly to the basic properties distinguishing TGD Universe from that of standard model. This allows to imagine that quantum jump leading from a superposition of space-time surfaces to a new one also gives rise to a representation of the conscious experiences which preceded the last quantum jump at the level of space-time geometry. Reductio ad absurdum would transform to evolution of consciousness able to add to the existing hierarchy a new reflective level in each quantum jump.

I have proposed several correlates for the self-referentiality of consciousness. Many-sheeted space-time would provide the physical representation (see Fig. http://tgdtheory.fi/appfigures/manysheeted.jpg or Fig. 9 in the appendix of this book).

Many-sheeted space-time and self-referentiality

The fractal hiearchy of magnetic flux tubes giving rise to braids, which in turn make possible topological quantum computation would be a rather realization of this representation, A possible concrete physical realization of self-referentiality is suggested by DNA as quantum computer model [K6]. One assumes that DNA nucleotides and lipids are connected by magnetic flux tubes. Since the lipid layer of the cell membrane is 2-dimensional liquid crystal, the lipids are in continual hydrodynamical motion and this means in time direction entanglement of the orbits. The events in nearby environment and also nerve pulses affect this flow. This braiding in time direction defines a topological quantum computation. This motion entangles also the flux tubes connecting the lipids to DNA nucleotides so that when the topological quantum computation halts it becomes stored into memory as space-like entanglement. In TGD framework also the time-like braiding provides a space-time representation of the quantum computation which also gives to a conscious experience at some level of the hierarchy.

Infinite primes and self-referentiality

The hierarchy of infinite primes (and of integers and rationals) [K124] was the first mathematical notion stimulated by TGD inspired theory of consciousness. The construction recipe is equivalent with a repeated second quantization of a super-symmetric arithmetic quantum field theory with bosons and fermions labeled by primes such that the many-particle states of previous level become the elementary particles of new level. At a given level there are free many particles states plus counterparts of many particle states. There is strong structural analogy with polynomial primes. For polynomials with rational coefficients free many-particle states would correspond to products of first order polynomials and bound states to irreducible polynomials with non-rational roots.

The hierarchy of space-time sheets with many particle states of space-time sheet becoming elementary particles at the next level of hierarchy. For instance, the description of proton as an elementary fermion would be in a well defined sense exact in TGD Universe. Also the hierarchy of n: th order logics are possible correlates for this hierarchy.

This construction leads also to a number theoretic generalization of space-time point since a given real number has infinitely rich number theoretical structure not visible at the level of the real norm of the number a due to the existence of real units expressible in terms of ratios of infinite integers. This number theoretical anatomy suggest a kind of number theoretical Brahman=Atman identity stating that the set consisting of number theoretic variants of single point of the embedding space (equivalent in real sense) is able to represent the points of WCW or maybe even quantum states assignable to causal diamond. One could also speak about algebraic holography.

The correspondence between the quantum states defined by WCW spinor fields and wave functions in the infinite-dimensional discrete space of hyper-octonionic units can be made more concrete [K124]. These wave functions must transforming irreducibly under discrete subgroup SU(3) of octonion automorpisms transforming ordinary hyper-octonionic prime to a new hyperoctonionic prime. SU(3) has interpretation as color group. One can assign standard model quantum numbers to these wave functions and prime property in principle fixes the spectrum of possible quantum states- in particular the spectrum of masses. Therefore the extremely esoteric looking notion of infinite prime might turn out to be very practical calculational tool.

Quantum Mathematics and self referentiality of consciousness

In Quantum Mathematics numbers are replaced with Hilbert spaces and the dimension of Hilbert space - in appropriately. generalized sense - characterizes the number.

- 1. This suggests a generalization of calculus for Hilbert spaces. Mathematical objects which are defined for numbers in various number fields become well defined when these numbers are replaced with Hilbert spaces. One can speak of the Hilbert space analogs of algebraic numbers, transcendentals, p-adic numbers and their extensions. Anything having as a building brick rationals, algebraic numbers, real or p-adic numbers or finite fields generalizes. Even the notions like matrix group, algebras, and ring generalize. Also the notion of manifold generalizes as well as the notion of calculus.
- 2. The Hilbert space in associated with the element of number field characterizes its number theoretic anatomy and therefore could be a correlate of cognition. The crucial step in the generalization of this process to the level of the Hibert space representing points. Points of Hilbert spaces can be replaced with Hilbert spaces and process can be repeated ad infinitum. This suggests that the self-referentiality at the deepest level corresponds to this fractal view about space-time based on assignment of quantum dynamics to numbers. Also a connection with the hierarchy of *n*: th order logics. A close relationship to infinite primes would not be surprising since in both cases one an infinite hierarchy of processes analogous to second quantization is involved. A natural question is whether many-sheeted space-time provides a dynamical representation in terms of space-time sheets for the number theoretic anatomy so that kind of Brahman=Atman identity or algebraic holography would hold true. This correspondence could be see as a cognitive representation of external world and one could also see the external world as symbolic representation of the world of cognition.
- 3. A connection with generalized Feynman diagrams and hierarchy of Planck constants is suggestive and the idea was originally inspired by the observation that the two vertices of generalized Feynman diagrams identifiable as generalizations of the basic stringy 3-vertex for closed strings and basic 3-vertex for Feynman diagrams correspond naturally to direct sum and tensor product in turn having natural correspondence with + and × of the usual arithmetics. This correspondence motivates the introduction of co-operations of direct sum and tensor product meaning that quantum dynamics is brought into the game through these vertices. This suggests that Quantum Mathematics is actually Quantum dynamics in which generalized Feynman diagrams define sequences of arithmetic or even more general algebraic operations.

If so, the basic structures of Quantum Mechanics (QM) might reduce to fundamental mathematical and metamathematical structures, and that one even consider the possibility that Quantum Mechanics reduces to Quantum Mathematics with mathematician included or expressing it in a concise manner: QM=QM!

The fractal character of the Quantum Mathematics is what makes it a good candidate for understanding the self-referentiality of consciousness. The replacement of the Hilbert space with the direct sum of Hilbert spaces defined by its points would be the basic step and could be repeated endlessly corresponding to a hierarchy of statements about statements or hierarchy of n^{th} order logics. The construction of infinite primes leads to a similar structure.

What about the step leading to a deeper level in hierarchy and involving the replacement of each point of Hilbert space with Hilbert space characterizing it number theoretically? What could it correspond at the level of states?

1. Suppose that state function reduction selects one point for each Hilbert space $x_n \times p^n$. The key step is to replace this direct sum of points of these Hilbert spaces with direct sum of Hilbert spaces defined by the points of these Hilbert spaces. After this one would select point from this very big Hilbert space. Could this point be in some sense the image of the Hilbert space state at previous level? Should one imbed Hilbert space $x_n \times p^n$ isometrically to the Hilbert space defined by the preferred state $x_n \times p^n$ so that one would have a realization of holography: part would represent the whole at the new level. It seems that there is a

canonical manner to achieve this. The interpretation as the analog of second quantization suggest the identification of the embedding map as the identification of the many particle states of previous level as single particle states of the new level.

- 2. Could topological condensation be the counterpart of this process in many-sheeted space-time of TGD? The states of previous level would be assigned to the space-time sheets topologically condensed to a larger space-time sheet representing the new level and the many-particle states of previous level would be the elementary particles of the new level.
- 3. If this vision is correct, second quantization performed by theoreticians would not be a mere theoretical operation but a fundamental physical process necessary for cognition! The above proposed unitary embedding would imbed the states of the previous level as single particle states to the new level. It would seem that the process of second quantization, which is indeed very much like self-reference, is completely independent from state function reduction and unitary process. This picture would conform with the fact that in TGD Universe the theory about the Universe is the Universe and mathematician is in the quantum jumps between different solutions of this theory.

Chapter 4

Life and Death and Consciousness

4.1 Introduction

Life and death have remained the deepest mysteries of science. The development of quantum theories of consciousness has however encouraged scientist to make also questions about the essence of life and death. In this article TGD based view about consciousness, about about life and death is discussed.

To begin with, it is good to represent the basic ideas of TGD inspired theory of consciousness.

1. Living system bring in mind elementary particle like coherent unit. This suggests that macroscopic quantum coherence is an essential aspect of life and consciousness. Non-predictability, which does not mean randomness, is second essential aspect of living systems and we experience it as free will. The description of this aspect however leads to problems in the materialistic approach originally inspired by physicalism and the idea that physicist can predict everything given the initial values.

State function reduction seems to be however a genuine non-deterministic physical phenomenon and leads to severe problems in quantum measurement theory: it is very difficult to combine the non-determinism of state function reduction with determinism of unitary time evolution (causality problem): this has led to a multitude of interpretations trying to avoid the paradox. The obvious first guess is that it might hold key to the understanding of consciousness.

2. TGD inspired quantum theory of consciousness can be seen as a generalization of quantum measurement theory replacing the notion of observer as kind of black box with the notion of self as conscious entity. In TGD framework causality problem is solved by assuming that there are two times: subjective time defined by sequence of state function reductions following the analog of unitary time evolution lasting for finite time and geometric time of physicist. Corresponding causalities are independent and quantum jump replaces entire time evolution with a new one so that the conflict between the causalities is resolved.

This picture leads to what I call Zero Energy Ontology (ZEO). In ZEO physical states are zero energy states, which are superpositions of pairs of positive and negative energy states serving as analogs of what might called classical event. They respect basic conservation laws and solution of field equations connects the members of state pair: this realizes holography. The members of pair are localized at boundaries of causal diamond (CD) obtained by taking the intersection of future and past directed light-cones of Minkowski space and replacing its points by CP_2 .

State function reduction occurs in cascade like matter proceeding to shorter scales and from system to the sub-system if system decomposes to a product of unentangled sub-systems in the reduction. The outcome at passive boundary of CD is a set of inherently negentropically entangled subsystems having no entanglement between themselves. These systems can be seen as sub-selves of self experiencing these subsystems as mental images. For given CD state function reduction occurs repeatedly to what I call passive (light-like) boundary of CD and leaves members of state pairs at it invariant. Also the passive boundary itself remains unchanged. The members of state pairs at opposite, *active* boundary of CD experiences the analog of unitary time evolution followed by a reduction passive boundary: this occurs repeatedly as in Zeno effect. Active boundary also drifts further away from the passive boundary whereas nothing happens at the passive boundary.

- 3. The basic variational principle of consciousness theory identified as quantum measurement theory is Negentropy Maximization Principle (NMP), which demands that entanglement negentropy associated with entanglement is not reduced. In real number based theory entanglement negentropy would be non-positive and genuine information would not be possible. The requirement that the theory describes also cognition, however leads to the generalization of real number based physics to what I call adelic physics. p-Adic number fields allow only algebraic number valued entanglement and assign to it negentropy, which can be positive. One has negentropic entanglement (NE) NMP allows several variants but the mildest form requiring that NE is not reduced seems to be the realistic one.
- 4. Self as conscious entity can be regarded as generalized Zeno effect identified as a sequence of state function reductions to the same (passive) boundary of CD not changing the part of state at it. Eventually the first reduction to opposite boundary takes place and self dies and re-incarnates as time reversed self at the opposite boundary of CD - obviously a highly non-trivial prediction of ZEO. The flow of subjective time can be interpreted as the increase of temporal distance between the tips of CD.

To help the reader to build a context it helps to summarize what TGD inspired consciousness is and what it is not. In particular, I try to make explicit those key assumptions of TGD, which are in conflict with the existing belief system. The basic assumptions of TGD as a theory can be certainly be blamed of being speculative but the basic predictions of TGD follow from these assumes and are not speculations in the framework of TGD.

1. The approach is that of physicist but not of physicalist. TGD tries to extend physics as a theory of regularities of conscious experience to a theory of consciousness. TGD does not try to reduce consciousness to a property of some system as physicalist would do, and therefore also avoids the hard problem plaguing monistic and dualistic approaches. For physicist the idea that consciousness would be assignable only to brain, human brain, or even male brain is extremely non-feasible and bring in mind the view about Earth as the center of Universe.

One could blame TGD for panpsychism. This kind of view is adopted also by Tononi and Koch in IIT approach [J90] (for TGD based criticism of IIT see [K130]). Self hierarchy is the key prediction challenging the standard neuroscience based view, and combined with the identification of sub-selves as mental images gives rise to a rather powerful and predictive approach. Hence in the following life and death are seen as universal notions expected to make sense in much wider framework than biological systems.

2. The experience from discussions is that the relationship between geometric and subjective times is difficult notion. In particular, understanding of how subjective time as a sequence of state function reductions (to the same boundary of causal diamond (CD)) corresponds to clock time has been one of the main challenges of TGD inspired theory of consciousness during the last two decades.

Existence is often thought to be just single type of existence but now conscious existence is assigned with state function reductions, something between two quantum worlds (objective existences in the sense of physics), which represent mathematical existence and are zombies. For a non-mathematician this notion is not easy to grasp. It is however extremely economical ontologically since it allows to get rid of the assumption that there is something "behind" the quantum worlds as mathematical realities. Conscious existence means continual re-creation of the quantum universe and together with NMP it implies evolution.

3. In ZEO physical states are replaced with something analogous to events, pairs of positive and negative energy states with opposite total quantum numbers. This is also new and difficult to

comprehend. For people thinking in terms eastern philosophies ZEO might be easier notion but for a "westener" the idea that there are only observations of events and that physical world as something absolute and given is only a narrative, looks weird. ZEO is of course consistent with the laws of physics, in particular conservation laws, but implies their scale dependence accepted already in quantum field theories.

ZEO can be also defended by its extreme flexibility allowing to avoid the usual problems causing grey hairs for theoretician. In classical physics initial values fix the entire time evolution and only single solution of field equations is realized: in strict sense theories are untestable and obsolete. One can also wonder what metaphysical principle selects the initial values. Also in quantum physics conservation laws restrict strongly the set of allow time evolutions and the idea about theory for entire Universe becomes somewhat obsolete.

- 4. The assumption about fixed arrow of time is not usually questioned. ZEO forces to give up this belief, and predicts the notions of time-reversed self and re-incarnation. These can be argued to be very weird predictions, and they might be of course wrong. This can be tested. TGD inspired theory of consciousness is indeed a theory and good theories usually predict something not consistent with naive everyday intuitions. Libet's strange findings about active aspect of consciousness [J15] could be understood if the arrow of time changes in motor actions.
- 5. The notion of macroscopic quantum coherence is central and represents new physics relevant for quantum biology. The new quantum biology comes from several sources: the hierarchy of Planck constants $h_{eff} = n \times h$ making possible macroscopic quantum coherence for large enough values of n assignable to dark matter as phases of ordinary matter so that dark matter would become key player in the drama of living matter.

Second new notion is what I call many-sheeted space-time. In field theory and general relativity limit of TGD the effects of many-sheeted space-time show as small anomalies [K122] but in biology this notion becomes central.

The third new notion is that of magnetic body (MB) deriving from the new view about classical fields implied by the postulate that space-times are 4-D surfaces in $M^4 \times CP_2$. Systems have field identity, field body, in particular magnetic body serving as intentional agent receiving sensory data from biological body and controlling it by using analog of EEG realized in terms of dark photons. Also this notion raises strong emotional reactions. I can only defend TGD by telling that this is what TGD naturally predicts, and I have done quite impressive work in finding anomalies where magnetic body raises its head.

6. There are proposals that the lattice-like structures formed by neurons in some brain regions could be mapped to discrete sets of 2-D hyperbolic space H^2 , possibly tesselations analogous to lattices of 2-D plane. The map is rather abstract: the points of tesselation would correlate with the statistical properties of neurons rather than representing their geometric positions as such.

In TGD framework zero energy ontology (ZEO) suggests a generalization of replacing H^2 with 3-D hyperbolic space H^3 . The magnetic body (MB) of any system carrying dark matter as $h_{eff} = nh_0$ provides a representation of any system (or perhaps vice versa). Could MB provide this kind of representation as a tesselation at 3-D hyperboloid of causal diamond (cd) defined as intersection of future and past directed light-cones of M^4 ? The points of tesselation labelled by a subgroup of SL(2, Z) or it generalization replacing Z with algebraic integers for an extension of rationals would be determined by its statistical properties.

The positions of the magnetic images of neurons at H^3 would define a tesselation of H^3 . The tesselation could be mapped to the analog of Poincare disk - Poincare ball - represented as t = T snapshot (t is the linear Minkowski time) of future light-cone. After t = T the neuronal system would not change in size. Tesselation could define cognitive representation as a discrete set of space-time points with coordinates in some extension of rationals assignable to the space-time surface representing MB. One can argue that MB has more naturally cylindrical instead of spherical symmetry so that one can consider also a cylindrical representation at $E^1 \times H^2$ so that symmetry would be broken from SO(1,3) to SO(1,2).

 $M^8 - H$ duality would allow to interpret the special value t = T in terms of special 6-D brane like solution of algebraic equations in M^8 having interpretation as a "very special moment of consciousness" for self having CD as geometric correlate. Physically it could correspond to a (biological) quantum phase transition decreasing the value of length scale dependent cosmological constant Λ in which the size of the system increase by a factor, which is power of 2. This proposal is extremely general and would apply to cognitive representations at the MB of any system.

- 7. Adelic physics leads to a number theoretic variant of quantum measurement theory. Together with ZEO this leads to a number theoretic model of quantum measurement using the unique discretization of space-time surface provided by cognitive representations of space-time surfaces using points whose M^8 coordinates belong to the extension of rationals defining the adele. The discrete dynamics in the Galois group of the extension of rationals is part of the cognitive dynamics.
- 8. Adelic physics, $M^8 H$ duality, and zero energy ontology lead (ZEO) to a proposal that the dynamics involved with "small" state function reductions (SSFRs) as counterparts of weak measurements could be basically number theoretical dynamics with SSFRs identified as reduction cascades leading to completely un-entangled state in the space of wave functions in Galois group of extension of rationals identifiable as wave functions in the space of cognitive representations. As a side product a prime factorization of the order of Galois group is obtained.

The result looks even more fascinating if the cognitive dynamics is a representation for the dynamics in real degrees of freedom in finite resolution characterized by the extension of rationals. If cognitive representations represent reality approximately, this indeed looks very natural and would provide an analog for adele formula expressing the norm of a rational as the inverse of the product of is p-adic norms. The results can be applied to the TGD inspired model of genetic code.

One can compress the general vision to following mnenomics: ZEO, CD, NMP, NE, and Zeno effect. In the sequel I describe TGD more precisely. The article [L54] gives a more detailed view about TGD, TGD inspired theory of consciousness, and TGD inspired quantum biology. Appendix of this article contains a summary of TGD inspired quantum biology.

4.2 TGD

General theory of relativity (GRT) plagued by the problem that the notions of energy and momentum are not well-defined for curved space-time time. The proposal for overcoming the energy problem (made 1977, thesis came 1982) was that space-times are not abstract 4-D manifolds but representable as 4-D surfaces in certain 8-dimensional space-time $H = M^4 \times CP_2$, which is empty Minkowski space M^4 with points replaced with certain very small 4-D space CP_2 fixed uniquely from the condition that standard model symmetries and standard model fields can be geometrized. This choice of H is uniquely fixed both by twistorial considerations [K132, K57] or by the condition that theory is consistent with standard model symmetries.

It soon turned out that the modification can be seen also as a generalization of string model with strings in 10-D space-time replaced with 3-D surfaces in 8-D H, whose "orbits" are identifiable as space-time surfaces. Recently the connection with string model picture has become much deeper. By strong form of holography (SH) 2-D string world sheets and partonic 2-surfaces carry the data needed to construct quantum states and construct solutions of field equations (preferred extremals). 4-D space-time is however necessary for quantum-classical correspond necessary to describe measurements.

TGD Universe is predicted to be fractal: this replaces the naïve Planck length scale reductionism with fractality for which the simplest realization would be p-adic length scale hypothesis emerging from p-adic thermodynamics and dark matter hierarchy. Non-trivial predictions emerge in all scales from Planck length to cosmology and this makes it very difficult to communicate TGD for colleagues believing firmly on naïve length scales reductionism. In what follows I will proceed from quantum TGD to classical TGD without starting from particle physics observations - it would be extremely boring to repeat same old arguments again and again and reader can find these arguments from [K146].

4.2.1 Quantum TGD

The basic idea is to generalize Einstein's program as geometrization of classical physics to geometrization of the entire quantum theory so all notions of quantum theory except state function reduction which is identified as basic building brick of conscious experience would reduce to geometry.

Reduction of quantum theory to Kähler geometry and spinor structure of WCW

The condition that the entire quantum theory is geometrized requires infinite-dimensional geometric structure instead of space-time and the "world of classical worlds" (WCW) identified roughly as the space of space-time surfaces is the natural identification [K39, K65].

 The construction of quantum TGD leads to a generalization of the notion of super-space of Wheeler and to construction of infinite-dimensional geometry that I call "World of Classical Worlds" (WCW) having rough mathematical identification as space of 3-surfaces in H (ZEO dictates the identification in more detail). The mere mathematical existence of WCW geometry fixes it essentially uniquely - this is true already for the loop spaces of string model [A17]
 - and therefore physics. A huge generalization of the symmetries of super-string models emerges giving hopes of understanding the theory.

The geometrization of hermitian conjugation of quantum theory requires that WCW allows complex structure its metric is Kähler metric [K65] and coded by Kähler function identified in terms of Kähler action for a preferred extremal: this gives direct connection with classical physics since induced Kähler form define classical U(1) field, for the U(1) factor of electroweak gauge group assignable with weak hyper-charge. twistor lift implies the presence of a volume term identifiable in terms of cosmological constant. It would bring also Planck length into the theory as the radius of twistor sphere [K132].

- 2. Quantum states are identified as classical WCW spinor fields so that there is no need to perform quantization and state function reduction is the only genuinely quantal aspect of TGD [K144, K109]. Spinor structure requires identification of gamma matrices anticommuting to WCW metric and if the metric is Kähler metric, the anti-commutation relations are completely analogous to those of fermionic oscillator operators and one can indeed express the gamma matrices as linear superpositions of fermionic oscillator operators at space-time surface. Second quantization at space-time level is a purely classical notion at WCW level and becomes geometrized in WCW context.
- 3. ZEO (Zero Energy Ontology) is an essential element of theory. Usually one assumes that in classical physics generalized positions and their time derivatives (generalized velocities) giving at given moment of time in 3-D snapshot of space-time dictated the time evolution. This has generalization to Schrödinger equation. One has initial value problem.

This Newtonian view does not work in TGD: boundary value problem provides a more natural formulation. The generalized positions at two moments of time are more natural data and the dynamical evolution connecting the two 3-D snapshots defines by holography more or less equivalent view about the situation. These pairs are analogous to classical events and one can construct as their quantum superpositions what I call zero energy states and quantum jumps are quantum events occurring between these classical events.

ZEO is much more flexible than ordinary ontology since any zero energy state can be created from vacuum whereas in standard classical ontology only one solution of field equations is realized and in principle it is not possible to test the theory without additional assumptions. ZEO is especially natural in biology and neuroscience: the notions like function, behavioral pattern, and habit are not easy to describe in terms of the state of organism as 3-D snapshot of time evolution. The two time=constant snapshots are actually replaced with past and future boundaries of CD, which is the intersection of future and past directed light-cones of Minkowski space with each point replaced with CP_2 . The ends of space-time surfaces are at the these boundaries. Zero energy states have opposite conserved quantum numbers at the opposite boundaries of CD: this guarantees that conservation laws are satisfied and the system is consistent with standard laws of physics. CDs form a fractal hierarchy. There are CDs within CDs and CDs can also overlap.

In order to avoid confusion it must be made clear that since WCW spinor fields and zero energy states are formally purely classical entities. Only the state function reduction replacing zero energy state (classical event) would be genuinely quantal element of the theory. The Wheelerism for this would be "Quantization without quantization".

4. The recent formulation for the notion of preferred extremal relies on strong form of General Coordinate Invariance (SGCI). SGCI states that two very different kinds of 3-surfaces can identified as fundamental objects. Either the light-light 3-D orbits of partonic 2-surfaces defining boundaries between Minkowskian and Euclidian space-time regions or the space-like 3-D ends of space-time surfaces at boundaries of CD (both ends!). If both choices are equally good, partonic 2-surfaces and their tangent space-data at the ends of space-time should be the most economic choice.

This eventually led to the realization that partonic 2-surfaces and string world sheets should be enough for the formulation of WCW geometry and quantum TGD [K38]. Classical fields in the interior of space-time surface would be needed only in quantum measurement theory, which demands classical physics in order to interpret the experiments. The outcome is SH stating that quantum physics should be coded by string world sheets and partonic 2-surfaces inside given CD. SH is very much analogous to the AdS/CFT correspondence but is much simpler: the simplicity is made possible by much larger group of conformal symmetries. 2-dimensionality of space-time regions carrying fermion field can be deduce also from the condition that electromagnetic charge is well-defined for spinor modes: this requires that W boson fields vanish and this implies in the generic case 2-D string world sheets. Number theoretic vision suggests the interpretation of string world sheets and partonic 2-surfaces as commutative or co-commutative sub-manifolds of the space-time having quaternionic (associative) tangent space as a 4-surface in the embedding space with octonionic (non-associative) tangent space [K126, K142].

If these 2-surfaces satisfy some consistency conditions one can continue them to 4-D spacetime surface inside CD such that string world sheets are surfaces inside them satisfying the condition that charged (possibly all) weak gauge potentials identified as components of the induced spinor connection vanish at the string world sheets and also that energy momentum currents flow along these surfaces. String world sheets carry second quantized free induced spinor fields and fermionic oscillator operator basis is used to construct WCW gamma matrices.

5. The existence of WCW geometry requires maximal possible group of symmetries for the geometry of WCW. Essentially a union of infinite-dimensional symmetric spaces labelled by so called zero modes not contribution to the line element of WCW would be in question. The natural candidate for this infinite-dimensional isometry group is symplectric group acting in CP_2 and at 3-D light-cone. This group maps vacuum extremals to vacuum extremals but is not a symmetry of more general extremals: if this were the case WCW metric would be trivial.

Quantum Criticality and hierarchy of Planck constants as dark matter hierarchy

The Kähler coupling strength α_K appearing in Kähler action is analogous to temperature. In its original form [K65] QC stated that this coupling strength is analogous to critical temperature and therefore has discrete spectrum. This idea makes sense even if Kähler action is generalized to contain additional terms: all coupling constants would be analogous to critical thermodynamical parameters.

Indeed, the twistor lift of TGD [K132, K57] replacing space-time surfaces with their twistor spaces in 12-dimensional product of twistor spaces of M^4 and CP_2 indeed brings in cosmological constant Λ and Planck length as radius of the sphere S^2 serving as the fiber of twistor space. This lift makes sense only for $M^4 \times CP_2$ making this choice unique. If Planck length and cosmological constant emerge in this manner their spectrum would be fixed by QC condition. The negative pressure implying accelerated cosmic expansion can be also assigned to magnetic flux tubes with monopole flux so that the situation remains open.

The meaning of QC at the level of dynamics has become only gradually clearer. The development of several apparently independent ideas generated for about decade ago have led to the realization that QC [?] is behind all of them. Behind QC are in turn number theoretic vision and strong forms of general coordinate invariance (GCI) and holography (SGCI and SH).

1. The hierarchy of Planck constants labelling a hierarchy of dark phases of ordinary matter corresponds to a hierarchy of quantum criticalities assignable to a fractal hierarchy of sub-algebras of the super-symplectic algebra assignable to the boundary of CD with points replaced with CP_2 . The conformal weights are *n*-ples of those for the entire algebra. These algebras are isomorphic to the full algebra and act as gauge conformal algebras so that a broken super-conformal invariance is in question. For n > 1 the hierarchy levels are interpreted in terms of dark matter. What is highly non-trivial that the conformal weights itself need not be integers or half integers as usually. The generators of algebra could have conformal weights which are proportional to zeros of zeta and poles of zeta so that the number of generating elements (finite for ordinary super-conformal algebras) would be infinite [K54]. Physical states would however have real conformal weights which would be half integers (conformal confinement).

Could *n* correspond to the value of effective Planck constant $h_{eff}/h = n$? Why *n* should correspond to the number of sheet for the space-time surface as covering space? It has become clear that there is no obvious reason why for this. Number theoretic vision provides much more feasible answer. Adelic hierarchy corresponds to a hierarchy of extensions of rationals and the Galois groups of extensions act as symmetry groups permuting number theoretic discretizations of space-time surface and combining them to single *n*-fold covering space, where *n* divides the the order of Galois group of the extension. These groups also act as autormorphism groups of the dynamical Kac-Moody groups assignable to the hierarchy of sub-algebras of the super-symplectic algebra.

2. QC in turn reduces to the number theoretic vision about SH. String world sheets carrying fermions and partonic 2-surfaces are the basic objects as far as pure quantum description is considered. Also space-time picture is needed in order to test the theory since quantum measurements always involve also the classical physics, which in TGD is an exact part of quantum theory.

SH says that space-time surfaces are continuations of collections of string world sheets and partonic 2-surfaces to preferred extremals of Kähler action for which Noether charges in the sub-algebra of super-symplectic algebra vanish. This condition is the counterpart for the reduction of the 2-D criticality to conformal invariance. This eliminates huge number of degrees of freedom and makes SH possible. TGD does not reduce physics to that of strings since the fact that strings are surfaces inside 4-D space-time surfaces is an essential part of physics and also the experimental testing requires 4-D space-time as also the notion of 8-D embedding space.

3. The hierarchy of algebraic extensions of rationals defines the values of the parameters characterizing the 2-surfaces, and one obtains a number theoretical realization of an evolutionary hierarchy. One can also algebraically continue the space-time surfaces to various number fields - reals and the algebraic extensions of p-adic number fields. Physics becomes adelic [K142].

p-Adic sectors serve as correlates for cognition and imagination. One can indeed have string world sheets and partonic 2-surfaces, which can be algebraically continued to preferred extremals in p-adic sectors by utilizing p-adic pseudo constants providing huge flexibility. If this is not possible in the real sector, a fragment of imagination is in question! It can also happen that only part of real space-time surface can be generated: this might relate to the fact that imaginations can be seen as partially realized motor actions and sensory perceptions.

- 4. The assignment of the hierarchy of Planck constant to a hierarchies of inclusions of hyperfinite factors of type II_1 is natural. Also the interpretation in terms of finite measurement resolution makes sense. As *n* increases the sub-algebra acting as conformal gauge symmetries is reduced so that some gauge degrees of freedom are transformed to physical ones. The transitions increasing *n* occur spontaneously since criticality is reduced. A good metaphor for TGD Universe is as a hill at the top of a hill at the top.... In biology this interpretation is especially interesting since living systems can be seen as systems doing their best to stay at criticality using metabolic energy feed as a tool to achieve this. Ironically, the increase of \hbar would mean increase of measurement resolution and evolution!
- 5. If twistor lift is not performed, the only coupling constant of the theory is Kähler coupling constant $\alpha_K = g_K^2/4\pi\hbar$, which appears in the definition of the Kähler function K characterizing the geometry of WCW. In the most general case α_K has a spectrum of critical values and this conjecture seems at this moment the most reasonable one. It has indeed turned out that the discrete spectrum could have interpretation in terms of discretized coupling constant evolution for U(1) coupling constant of standard model. The identification of the spectrum in terms of zeros of so called fermionic zeta function expressible in terms of Riemann zeta is attractive [K54]. The exponent of K defines vacuum functional analogous to the exponent of Hamiltonian in thermodynamics. The allowed values of $\alpha_K = g_K^2/4\pi\hbar_{eff}$ should be analogous to critical temperatures and determined by QC requirement.

4.2.2 Classical TGD

In TGD framework classical physics is an exact part of quantum physics rather than being only an approximate limit of quantum theory emerging from the stationary phase approximation to path integral, which would in TGD allow all space-time surfaces. Now one does not have path integral but functional integral over the pairs of 3-surfaces at bounaries of CD. Only preferred extremals of Kähler are allowed in the functional integral so they satisfy classical field equations and even more: effective 2-dimensionality holds by SH. Stationary phase approximation can be made also now but selects "preferred preferred extremals". The reason is that for real value of α_K the Minkowskian space-time regions give imaginary exponent to the action exponential whereas Euclidian space-time regions give real exponent identifiable as exponent of Kähler function. In fact, the value of α_K can be also complex but this does not affect this picture.

Space-time surfaces as preferred extremals of Kähler action

Preferred extremal of Kähler action have remained for a long time one of the basic poorly defined notions of TGD. There are pressing motivations for understanding what "preferred" really means. For instance, the conformal invariance of string models naturally generalizes to 4-D invariance defined by quantum Yangian of quantum affine algebra (Kac-Moody type algebra) characterized by two complex coordinates and therefore explaining naturally the effective 2-dimensionality [K132].

In ZEO preferred extremals are space-time surfaces connecting two space-like 3-surfaces at the ends of space-time surfaces at boundaries of CD. A natural looking condition is that the symplectic Noether charges associated with a sub-algebra of symplectic algebra with conformal weights n-multiples of the weights of the entire algebra vanish for preferred extremals. These conditions would be classical counterparts the condition that super-symplectic sub-algebra annihilates the physical states.

What is needed is the association of a unique space-time surface to a given 3-surface defined as union of 3-surfaces at opposite boundaries of CD. One can imagine many ways to achieve this. "Unique" is probably too much to demand: for the proposal unique space-time surface is replaced with finite number of conformal gauge equivalence classes of space-time surfaces. This would bring in finite number of discrete degrees of freedom. In any case, it is better to talk just about preferred extremals of Kähler action and accept as the fact that there are several proposals for what the precise meaning of this notion.

Many-sheeted space-time and topological field quantization

At classical level the basic is the notion of many-sheeted space-time which can be visualized in 2-D situation as a structure consisting of space-time sheets extremely near to each other and connected by wormhole contacts. General Relativity becomes approximate description obtained by replacing the sheets with single slightly curved region of Minkowski space. The sheets correspond to material objects that one can say that we directly see them. The experimental tests distinguishing TGD from GRT relate to many-sheetedness.

Preferred extremal property implies extremely powerful quantization conditions as is clear from the fact that the 2-D data should fix the preferred extremal by SH.

The quantum field theory limit of TGD - GRT plus standard model - is obtained when the sheets are compressed to single region of slightly curved piece of M^4 by identifying gauge potentials as sums of induced gauge potentials for the spinor connection of CP_2 and gravitational field as sum for the deviations of the induced metrics from Minkowski metric. This corresponds to the vision that the force experienced by a test particle - small 4-surface - is sum of those induced as it touches various space-time sheets. One gets rid of topological complexity but the extreme simplicity of space-time dynamics is lost in this replacement.

The compactness (finite size) CP_2 implies topological field quantization: the classical electric fields, magnetic fields, and radiation fields decompose to topological field quanta, space-time sheets, and one can say that physical systems have field identity, field body. This is not true in Maxwell's theory.

The notion of magnetic body carrying dark matter identified as macroscopically quantum coherent $h_{eff} = n \times h$ phases has become central in TGD inspired quantum biology [K99, K98]. Magnetic body becomes intentional agent using biological body as a sensory receptor and motor instrument. Communication and control would be based EEG and its fractally scaled variants consisting of dark photons. The size of magnetic body is rather large, at EEG frequency range the size scale is defined by the wave length of photons involved and is of the order of the size scale of Earth. The proposal is that bio-photons are created in a phase transition transforming dark photons to ordinary photons [K20]: since bio-photons have energies are in the range of visible and UV photons, this requires that the value of h_{eff}/h is roughly the ratio of the frequency of EEG photon with the frequency of visible photon and rather large.

I have called radiation quanta "massless extremals" (MEs) or topological light rays. For MEs the signals propagate at maximal signal velocity (for general space-time sheet light velocity is reduced since the paths along curved space-time sheet is general longer) and thanks to the tubular structure of ME they represent precisely target communications. A further property is that the shape of signal is preserved since positive frequency can propagate in one direction only.

New ontology

TGD leads to a new ontology at both space-time level and quantum level.

- 1. At space-time level many-sheeted space-time represents new piece of ontology. Single spacetime sheet is extremely simple objects and the information needed to construct it is by SH 2-dimensional. Complexity emerges at quantum field theory limit when the sheets of the many-sheeted space-time are replaced with single slightly curved region of M^4 .
- 2. The hierarchy of Planck constants identified in terms of dark matter as phases of ordinary matter represents second new ontological element. Dark matter is assumed to reside at magnetic body which also represents a new ontological element.
- 3. A further modification of ontology is the replacement of the usual positive energy ontology (PEO) with what I call ZEO already described. In ZEO quantum states are superpositions of quantum evolutions connecting the positive and negative energy parts of the states. Zero energy states are essentially 4-D and only the positive and negative energy parts are 3-D. Quantum jumps/state function reductions re-create the zero energy states with new ones and this allows to solve the basic paradox of ordinary quantum measurement theory due to the fact that non-determinism of state function reduction is in conflict with the determinism of unitary time evolution. One also ends up with identification of "self" as conscious entity:

self corresponds to generalized Zeno effect: to a sequence of state function reduction to say positive (positive) energy part of zero energy state [K13] [L58]. Self dies when the first reduction to negative (positive) part occurs. Also the origin for the flow of experienced time can be understood.

Hierarchies

TGD Universe is characterized by various hierarchies. At space-time level there is a hierarchy of space-time sheets labelled by a hierarchy of p-adic length scales coming as primes near powers of two and probably generalizing to primes near powers of prime [K86, K142]. In ZEO and at embedding space level there is a hierarchy of CDs labelled by their size scales coming as integer multiples of CP_2 scales. The fractal hierarchy of symplectic sub-algebras leads to a generalization of quantum theory based on a hierarchy of Planck constants characterizing hierarchy of dark matters [K55, ?], hierarchies of inclusions of hyper-finite factors [K143], hierarchies of breakings of super-symplectic gauge symmetry [K144, K109] associated with a hierarchy of quantum criticalities [?]. There is also a number theoretic hierarchy of algebraic extensions of rationals accompanied by those of p-adic number fields [K142] allowing to see evolution as a gradual increase of the complexity for extensions of rationals assignable to the parameters characterizing string world sheets and partonic 2-surfaces. In TGD inspired theory of consciousness [K76] self hierarchy emerges.

At the basic level the fundamental hierarchy seems to be the heirarchy of breakings of supersymplectic symmetry as gauge symmetry. Super-symplectic algebra and its Yangian generalization have the structure of conformal algebra and is naturally associated with critical systems which are now 4-dimensional. There are also other conformal algebras involved.

By SH implied by the SGCI the core of the mathematical description of quantum TGD reduces to that for 2-D systems associated with partonic 2-surfaces and string world sheets. Although space-time is 4-D, all that can be said mathematically about quantum physics can be reduced to these 2-D "space-time genes". 4-D space-time surfaces are however necessary for the classical description of TGD necessary to interpret quantum measurements in terms of frequencies and wavelengths classical space-time picture about particles. This reduction implies that the representations of charges of super-symplectic Yangian [K132, K57] are in terms of fermionic strings connecting partonic 2-surfaces, which means enormous simplification of the theory. This representation also involves a generalization of AdS/CFT duality to TGD framework as manifestation of SGCI basically [K38].

4.2.3 Number theoretical physics

Number theoretical physics involves several threads [K142].

- 1. p-Adic physics as correlate for cognition, imagination, and intentionality [K125] p-Adic physics was originally inspired by the challenge of understanding the mass scales of elementary particles but it soon turned that the interpretation in terms of mathematical correlates of cognition and imagination is very natural. This in turn forced the conclusion that cognition is probably present in all length scales, rather than only at the level of brain. The eventual outcome was a fusion of real and p-adic physics in terms of adelic physics.
- 2. Classical number fields emerge very naturally in TGD framework [K126]. For instance, the conjecture is that space-time surfaces as preferred extremals of Kähler action are quaternionic sub-manifolds of embedding space endowed with octonionic structure. Also quaternion analyticity [A44, A34] as a generalization of complex analyticity central in string models is very attractive conjecture [K132] in accordance with the original vision that 2-D analyticity in some sense generalizes to its 4-D variant.
- 3. Infinite primes [K124] are constructed by a repeated second quantization of arithmetic quantum field theory and could be essential for understand of quantum TGD.

In the sequel I discuss only the p-adic physics and the fusion of real physics and various p-adic physics to adelic physics as proposal for the physics of matter and mind or correlates of sensory and cognitive consciousness.

p-Adic physics as physics of cognition, imagination and intentionality

- 1. The attempt to understand elementary particle mass spectrum led to the hypothesis that p-adic number fields - one for each prime p = 2, 3, 5, ..., which are completions of rationals like real numbers, allow to construct what I called p-adic thermodynamics allowing to understand particle masses as kind of thermal masses resulting when massless particles suffer slight thermal mixing with particles with mass scale given by CP_2 mass of order 10^{-4} Planck masses.
- 2. The failure of well-orderedness property for p-adic numbers brings in the corresponding failure due to a finite measurement resolution and leads to the vision that p-adic numbers are ideal for describing the effects of finite measurement resolution and cognitive resolution.
- 3. The failure of strict determinism for the partial differential equations suggest strongly that it serves as a correlate for cognition, imagination, and maybe also intention is closely related.
- 4. The fusion of real physics and various p-adic physics (identified as correlates for cognition, imagination, and intentionality) to single coherent whole leads to adelic physics [K142]. Adeles associated with given extension of rationals are Cartesian product of real number field with all p-adic number fields extended by the extension of rationals. Besides algebraic extensions also the extension by any root of e is possible since it induces finite-dimensional p-adic extension. One obtains hierarchy of adeles and of corresponding adelic physics interpreted as an evolutionary hierarchy.

An important restriction is that p-adic Hilbert spaces exist only if one restricts the p-adic numbers to an algebraic extension of rationals having interpretation as numbers in any number field. This is due to the fact that sum of the p-adic valued probabilities can vanish for general p-adic numbers so that the norm of state can vanish. One can say that the Hilbert space of states is universal and is in the algebraic intersection of reality and various p-adicities.

5. One can define the p-adic counterparts of Shannon entropy for all finite-dimensional extensions of p-adic numbers, and the amazing fact is that these entropies can be negative and thus serve as measures for information rather than for lack of it. The formula is simple:

$$S = -\sum_{k} P_k log(P_k) \to \sum_{k} P_k log(N_p(P_k)) \quad .$$

$$(4.2.1)$$

Here $N_p(x)$ is the p-adic norm, which for *n*-D extension is defined as *n*:th root of the determinant of the matrix of the linear map defined by multiplication with *x*. The change of sign is dictated by the fact that converging Boltzmann weights $e^{-E/kT}$ must in be TGD proportional to positive powers p^k with increasing *k* by the properties of p-Adic norm.

p-Adic entropy can have both signs bit NMP suggests that the sign tends to become negative so that interpretation as a measure for conscious information is possible. Furthermore, all non-vanishing p-adic negentropies are positive and the number of primes contributing to negentropy is finite since any algebraic number can be expressed using a generalization of prime number decomposition of rational number. These p-adic primes characterize given systen, say elementary particle.

The possibility of NE together with NMP [K80] implies that the reduction does not always lead to an unentangled state but can generate NE. Living systems would be systems generating NE and biological evolution could be seen as a gradual generation of negentropic resources - I have called them Akashic Records. For rational probabilities entanglement negentropy equals to real entropy [L53]. This might relate to the Jeremy Englands vision that high entropy is relevant for living matter.

What is important that entanglement negentropy and thermodynamical entropy are *not* negatives of each other. Hence NMP is not in conflict with the second law but predicts it for the ordinary matter as a consequence of non-determinism of state function reduction. It is

however true that large entropic recources realized as a large number of states with the same energy makes possible both large thermodynamical entropy and NE with large negentropy.

The extension of real physics to adelic physics

In TGD framework cognition is described in terms of p-adic number fields and has led to a fusion of real and various p-adic physics to what I call adelic physics [K142]. Real physics corresponds to sensory experience and p-adic physics to cognition and imagination. Originally I talked about p-adic physics as physics of cognition and intentionality but I have have become ambivalent about intentionality: this issue remains unsettled.

Real-p-adic correspondence has been a longstanding problem. Continuous correspondence at space-time level does not respect symmetries. Algebraic correspondence respects symmetries but not continuity. Also GCI has been a problem. In the proposed framework real-p-adic correspondence can be realized in elegant manner without conflict with fundamental symmetries and achieving continuity only for discretization.

- 1. The naïve idea is that rationals belong to the intersection of reals and p-adics. More generally, points in algebraic extension of rationals would be common to realities and p-adicities which correspond to "thought bubbles" or imaginations. This hierarchy defines a hierarchy of adeles having interpretation in terms of evolution leading to increasingly complex algebraic extensions of rationals.
- 2. The first guess was that this means at space-time level that embedding space points with rational valued coordinates (or values in the extension of rationals) correspond to common points of real and p-adic space-time surfaces. This picture however leads to problems with both GCI and key symmetries of TGD. What are the preferred coordinates of space-time surface which would be in algebraic extension of rationals in the intersection? Should one restrict symmetry groups to their discrete subgroups?
- 3. A partial resolution of the problem came from the realization that the intersection of realities and p-adicities corresponds to space-time surfaces, whose representation is such that they make sense both in real and p-adic sense [K142]. This requires that the WCW coordinates of these surfaces are invariant under various symmetries and general coordinate transformations of space-time belong to the extension of rationals in question. At the level of WCW the coordinates are highly unique on basis of symmetries and by GCI at space-time level. This also means discretization of the infinite-dimensional WCW and together with huge isometry group of WCW gives hopes about computatibility of TGD.
- 4. As often happens, also the original idea about points of given algebraic extension of rationals as common to real and p-adic space-time surfaces makes sense: one can say that these discrete points define cognitive representations in the real world. The point is that spacetime surfaces can be identified as 4-surfaces in H and discretization is induced by that of H. At the first step, the pieces of hyperboloids inside CD and CP_2 can be replaced with their discrete variants making sense both in real and p-adic sense [L56].

The discretization of space-time surface is *induced* by the discretization at the level of $CD \times CP_2$ in terms of algebraic points of space-time surface and one avoids problem with p-adic version of general coordinate invariance and various space-time symmetries because for coset spaces the coordinate choice is unique apart from isometries: angles or hyperbolic angles serve as coordinates. Angles do not exist in p-adic context. The phases $exp(i\phi)$ - and therefore the values of trigonometric functions - exist in algebraic extensions of p-adic numbers as roots of unity associated with angles $\phi_{m,n} = m2\pi/n$. Also the roots $e^{m/n}$ define finite-D extension of p-adic numbers since e^p is ordinary p-adic number.

The outcome is a precise mathematical formulation for the p-adic counterparts of space-time surfaces as preferred extremals of Kähler action. The p-adic variants of coset spaces can be seen as discretizations of real coset spaces with discrete points replaced by p-adic continua analogous to the monads of Leibniz [L56]. This would make possible discretization without loosing differentiability central for field equations. One can define p-adic field equations inside these monads and strong SH makes sense in both real and p-adic sector.

The same algebraic expressions would describe real and p-adic solutions of field equations locally when restricted to string world sheets and partonic 2-surfaces (maybe also their light-like orbits). Inside monads real-p-adic correspondence would respect algebraic structures and symmetries. In the intersections symmetry groups would be replaced with discrete subgroups and continuity would be respected in the approximation provided by discretization and would confirm with the idea about finite measurement resolution.

5. This procedure is unique for given choice of discrete subgroups G and H. One can however take any discrete subgroup with matrix elements in algebraic extension of rationals and its subgroup and form a discrete analog of coset space: there is infinite hierarchy of measurement/cognitive resolutions. For instance, in the case of SU(2) these discrete approximations of SU(2) containing finite set of points correspond to the discrete subgroups labelling inclusions of hyperfinite factors of type II_1 and include only Platonic solids as genuinely 3-D approximations of sphere. This is discrete structure in real world.

p-Adic physics as physics of imagination

A further step in the progress came from the discovery of SH [K38]. 2-dimensional surfaces (string world sheets and partonic 2-surfaces) are fundamental objects and 4-D physics is a kind of algebraic continuation from this intersection of reality and various p-adicities in both real and p-adic sectors of the adelic Universe. 4-D space-time surfaces are preferred extremals of Kähler action making them effectively 2-D in the sense that the 2-D surfaces serve as "space-time genes". Also the quantum states assignable to the 2-D surfaces can be algebraically continued to the entire 4-D space-time.

It is however quite possible that the continuation in the real sector to a preferred extremal of Kähler action fails. In p-adic sectors the possibility of p-adic pseudo constants, which are piecewise constant functions with vanishing derivative, makes the continuation much easier. This inspires the idea that imagination corresponds to these p-adic continuations. p-Adic continuation might be possible whereas real continuation could fail: one would have imagined world, which cannot be realized as often happens!

This argument becomes more precise as one realizes that SH is slightly broken: even information theoretically one has only effective 2-dimensionality [K142]. This means that 4-surfaces as preferred extremals are dictated by the data at string world sheets and possibly also partonic 2-surfaces and by data discrete set of points with preferred embedding space coordinates in the extension of rationals defining the adele structure by inducing the extensions of p-adic number fields. For p-adic number fields pseudo-constants make it easy to construct the algebraic continuation to a preferred extremal containing the discretization. For reals this is possible only in special cases. These discretizations correspond to realizable imaginations.

Note that Galois group acts as symmetries in the space of space-time discretizations and under certain conditions gives rise to a space-time surface, which is a covering space with n sheets, n a factor of the order of Galois group. The identification $h_{eff}/h = n$ is natural and reduces the hierarchy of Planck constants and dark matter to adelic physics. Ramified primes for the extension of rationals involved are preferred for extension and if the extension allows especially many realizable imaginations, it is surviver in the number theoretic fight for survival. Ramified primes for these extensions should be winners in the number theoretic evolution. Whether p-adic length scale hypothesis and its generalization follow from this conjecture, remains an open question.

Negentropic entanglement (NE)

In a given p-adic sector the entanglement entropy is defined by replacing the logarithms of probabilities in Shannon formula by the logarithms of their p-adic norms as already described. The resulting entropy satisfies the same axioms as ordinary entropy but makes sense only for probabilities, which are rational valued or in an algebraic extension of rationals. The algebraic extensions corresponds to the evolutionary level of system and the algebraic complexity of the extension serves as a measure for the evolutionary level. p-Adically also extensions determined by roots of e can be considered. What is so remarkable is that the number theoretic entropy can be negative.

A simple example allows to get an idea about what is involved. If the entanglement probabilities are rational numbers $P_i = M_i/N$, $\sum_i M_i = N$, then the primes appearing as factors of N correspond to a negative contribution to the number theoretic entanglement entropy and thus to information. The factors of M_i correspond to negative contributions. For maximal entanglement with $P_i = 1/N$ in this case the entanglement entropy is negative. The interpretation is that the entangled state represents quantally concept or a rule as superposition of its instances defined by the state pairs in the superposition. Identity matrix means that one can choose the state basis in arbitrary manner and the interpretation could be in terms of "enlightened" state of consciousness characterized by "absence of distinctions". In general case the basis is unique.

Metabolism is a central concept in biology and neuroscience. Usually metabolism is understood as transfer of ordered energy and various chemical metabolites to the system. In TGD metabolism could be basically just a transfer of NE from nutrients to the organism. Living systems would be fighting for NE to stay alive (NMP is merciless!) and stealing of NE would be the fundamental crime.

TGD has been plagued by a longstanding interpretational problem: can one apply the notion of number theoretic entropy in the real context or not. If this is possible at all, under what conditions this is the case? How does one know that the entanglement probabilities are not transcendental as they would be in generic case? There is also a second problem: p-adic Hilbert space is not a well-defined notion since the sum of p-adic probabilities defined as moduli squared for the coefficients of the superposition of orthonormal states can vanish and one obtains zero norm states.

These problems disappear if the reduction occurs in the intersection of reality and p-adicities since here Hilbert spaces have some algebraic number field as coefficient field. By SH the 2-D states states provide all information needed to construct quantum physics. In particular, quantum measurement theory.

- 1. The Hilbert spaces defining state spaces has as their coefficient field always some algebraic extension of rationals so that number theoretic entropies make sense for all primes. p-Adic numbers as coefficients cannot be used and reals are not allowed. Since the same Hilbert space is shared by real and p-adic sectors, a given state function reduction in the intersection has real and p-adic space-time shadows.
- 2. State function reductions at these 2- surfaces at the ends of CD take place in the intersection of realities and p-adicities if the parameters characterizing these surfaces are in the algebraic extension considered. It is however not absolutely necessary to assume that the coordinates of WCW belong to the algebraic extension although this looks very natural.
- 3. Does NMP apply to the sum of real and p-adic entropies (Option 1) or only to the sum of p-adic entanglement entropies (which can be negative) (Option 2). The situation is not settled yet.
 - (a) For Option 1 the total entropy vanishes identically for *rational* probabilities and NMP would say nothing about the situation [L53]. NMP would not prevent or favor state function reduction. It is not clear whether this situation corresponds to that in the physics of ordinary matter as opposite to that of living matter. For algebraic probabilities there would be a competition between real and p-adic sectors and p-adic sectors would win for algebraic extensions in the sense that p-adic entropy would be larger than real entropy.
 - (b) For Option 2 NMP would stabilize NE also for rational probabilities. One can wonder whether one obtains the ordinary state function reduction at all for this option. In ZEO state function reductions to the opposite boundary of CD would be however forced to occur and second law would be the outcome also in this case.

For both options it could quite well happen that NMP for the sum of real and p-adic entanglement entropies does not allow the ordinary state function reduction to take place since p-adic negative entropies for some primes would become zero and net negentropy would be lost.

In both cases mind would have causal power: it can stabilize quantum states against state function reduction and tame the randomness of quantum physics in absence of cognition! Can one interpret this causal power of cognition in terms of intentionality? If so, p-adic physics would be also physics of intentionality as originally assumed.

A fascinating question is whether the p-adic view about cognition could allow to understand the mysterious looking ability of idiot savants (not only of them but also of some greatest mathematicians) to decompose large integers to prime factors. One possible mechanism is that the integer N represented concretely is mapped to a maximally entangled state with entanglement probabilities $P_i = 1/N$, which means NE for the prime factors of P_i or N. The factorization would be experienced directly.

One can also ask, whether the other mathematical feats performed by idiot savants could be understood in terms of their ability to directly experience - "see" - the prime composition (adelic decomposition) of integer or even rational. This could for instance allow to "see" if integer is say 3rd - power of some smaller integer: all prime exponents in it would be multiples of 3. If the person is able to generate an NE for which probabilities $P_i = M_i/N$ are apart from normalization equal to given integers M_i , $\sum M_i = N$, then they could be able to "see" the prime compositions for M_i and N. For instance, they could "see" whether both M_i and N are 3rd powers of some integer and just by going through trials find the integers satisfying this condition.

4.3 ZEO and generalization of quantum measurement theory to a theory of consciousness

TGD inspired theory of consciousness is based on certain basic assumptions such as the identification of state function reduction as a measurement of universal observable identified density matrix characterizing entanglement and Negentropy Maximization Principle (NMP) as fundamental principle. Both the adelic approach and the notion of "World of Classical Worlds" (WCW) force to challenge these assumptions.

4.3.1 Questions

Do all state function reductions correspond to measurements of density matrix?

The earlier approach has assumed that state function reduction always corresponds to a measurement of density matrix serving as a universal observable. Measurement of density matrix allows to measure simultaneously arbitrary number of commuting observables by assuming to be a function of product of measured commuting observables represented as matrices. This makes sense at space-time level but at the level of WCW one encounters difficulties. For instance, the choice of quantization axis corresponds to a higher level choice localization to a sector of WCW with moduli characterizing this choice. Also the measurement of $h_{eff}/h = n$ measuring the dimension of Galois group would make sense and force a localization to an extension with Galois group with this dimension. Single entanglement between different points of WCW is not possible (WCW spinor field is analogous to classical spinor describing single particle state and no second quantization is assumed at the level of WCW and one has complete locality), this selection cannot correspond to a measurement of density matrix.

But is the measurement of density matrix really the only possible quantum measurement and does it correspond to act of goal directed intentional free will? Density matrix characterizes entanglement with environment. Is the measurement of density matrix only a reaction: a choice amongst given alternatives. Eastern philosophers make a sharp distinction between real intentional action and mere reaction. For instance, Krishnamurti talks a lot about this and sees that basically all problems of human kind is that we have not been able to transcend to the level at which our actions would be more than reactions.

Genuine intentional actions would very naturally correspond to self measurements realized as WCW localitions such as fixing the quantization axis, or selecting the extension of rationals defining particular evolutionary level of adele hierarchy, or choosing the boundary of CD at which state function reductions occur (arrow of geometric time) are possible.

Is NMP a fundamental principle or does it follow from adelic physics?

NMP has been regarded as a fundamental principle of TGD inspired theory of consciousness. Adelic approach however strongly suggests the reduction of NMP to number theoretic physics somewhat like second law reduces to probability theory: there would be no need to postulate NMP as a separate principle and NMP would hold true only in statistical sense so that we would not live in the best possible world as strongest form of NMP would imply. The dimension of the extension rationals characterizing the hierarchy level of physics and defined an observable measured in state function reductions is positive and can only increase in statistical sense. Therefore the maximal value of entanglement negentropy increases as new entangling number theoretic degrees of freedom emerge. $h_{eff}/h = n$ identifiable as factor of Galois group of extension characterizes the number of these degrees of freedom for given space-time surfaces as number of its sheets.

This forces to re-think what happens in the state function reduction in which the passive boundary of state function reduction becomes opposite boundary meaning death of self and its re-incarnation as time-reversed self: this reduction has been seen as strongest support for NMP as fundamental principle rather than consequence of adelic physics. The new view relies of the observation that the states at passive boundary are eigenstates of some observables, call them passive observables. The reductions at active boundary must correspond to measurements of observables commuting with the passive observables. Self as a generalized Zeno effect can live only as long as it is able to measure observables commuting with the passive ones. The increase the dimension of extension of rationals in unitary time evolutions between reductions - number theoretic evolution - could generate new observables commuting with the passive observables. Self lives as long as it evolves.

In the sequel I describe briefly the basic of TGD inspired theory of consciousness as generalization of quantum measurement theory to ZEO (ZEO), describe the definition of self, consider the question whether NMP is needed as a separate principle or whether it is implied is in statistical sense by the unavoidable statistical increase of $n = h_{eff}/h$ if identified as a factor of the dimension of Galois group extension of rationals defining the adeles, and finally summarize the vision about how p-adic physics serves as a correlate of cognition and imagination.

In the sequel I will use some shorthand notations for key principles and notions. General Coordinate Invariance (GCI); World of Classical Worlds (WCW); Strong Form of GCI (SGCI); Strong Form of Holography (SH); Preferred Extremal (PE); Zero Energy Ontology (ZEO); Negentropy Maximization Principle (NMP); Negentropic entanglement (NE) are the most often occurring acronyms.

4.3.2 ZEO

One must generalize ontology in order to solve the contradiction between deterministic time evolution and the evolution by state function reductions. This requires understanding the notion of subjective time and its relationship to the geometric time. The new ontology must allow to see selves as something unchanged in some aspects and continually changing in some other aspects. Also the experience about the flow of subjective time must be explained.

- 1. In TGD framework the answer is ZEO [K80]. The concept of quantum state is generalized. States are now analogs for physical events characterized by initial and final quantum state that is pairs of positive and negative energy states. The conserved quantum numbers of the members are opposite so that zero energy states can be created from vacuum. This is a radical generalization of the physicalist world of view but entirely consistent with conservation laws: there is no need to give laws of physics in order to have free will. Positive and negative energy parts of the zero energy states can be assigned to opposite light-like boundaries of CDs, which are intersections of future and past directed light-cones multiplied by CP_2 . CDs form a fractal scale hierarchy. They can be seen as embedding space correlates for the 4-D perceptive fields of selves.
- 2. CD is a central notion in ZEO and serves as embedding space correlate for self. State function reduction can occur to either boundary of CD ("upper" or "lower"). Self can be seen as a generalized Zeno effect a sequence of state function reductions to either boundary of CD.

These two kinds of selves can be said to be time reversals of each other. The period of nonboiling pot corresponds to the passive boundary of CD not changing in the reductions: also the parts of zero energy states at this boundary remain unaffected. The opposite - active boundary is shifted towards future reduction by reduction and states at it are changed. The shifting the geometric future gives rise to the experienced time flow. This is the analog of unitary time evolution.

4.3.3 From quantum measurement theory to a theory of consciousness

The notion of self can be seen as a generalization of the poorly defined definition of the notion of observer in quantum physics. In the following I take the role of skeptic trying to be as critical as possible.

The original definition of self was as a subsystem able to remain unentangled under state function reductions associated with subsequent quantum jumps. The density matrix was assumed to define the universal observable. Note that a density matrix, which is power series of a product of matrices representing commuting observables has in the generic case eigenstates, which are simultaneous eigenstates of all observables. Second aspect of self was assumed to be the integration of subsequent quantum jumps to coherent whole giving rise to the experienced flow of time.

Self as generalized Zeno effect

The precise identification of self allowing to understand both of these aspects turned out to be difficult problem. I became aware the solution of the problem in terms of ZEO (ZEO) only rather recently (2014).

- 1. Self corresponds to a sequence of quantum jumps integrating to single unit as in the original proposal, but these quantum jumps correspond to state function reductions to a fixed boundary of causal diamond CD leaving the corresponding parts of zero energy states invariant "small" state function reductions. The parts of zero energy states at second boundary of CD change and even the position of the tip of the opposite boundary changes: one actually has wave function over positions of second boundary (CD sizes roughly) and this wave function changes. In positive energy ontolo1gy these repeated state function reductions would have no effect on the state (Zeno effect) but in TGD framework there occurs a change for the second boundary and gives rise to the experienced flow of time and its arrow and self: self is generalized Zeno effect.
- 2. The first quantum jump to the opposite boundary corresponds to the act of "free will" or birth of re-incarnated self. Hence the act of "free will" changes the arrow of psychological time at some level of hierarchy of CDs. The first reduction to the opposite boundary of CD means "death" of self and "re-incarnation" of time-reversed self at opposite boundary at which the the temporal distance between the tips of CD increases in opposite direction. The sequence of selves and time reversed selves is analogous to a cosmic expansion for CD. The repeated birth and death of mental images could correspond to this sequence at the level of sub-selves.
- 3. This allows to understand the relationship between subjective and geometric time and how the arrow of and flow of clock time (psychological time) emerge. The average distance between the tips of CD increases on the average as along as state function functions occur repeatedly at the fixed boundary: situation is analogous to that in diffusion. The localization of contents of conscious experience to boundary of CD gives rise to the illusion that universe is 3-dimensional. The possibility of memories made possibly by hierarchy of CDs demonstrates that this is not the case. Self is simply the sequence of state function reductions at same boundary of CD remaining fixed and the lifetime of self is the total growth of the average temporal distance between the tips of CD.

State function reductions at the level of WCW

One can identify several rather abstract state function reductions selecting a sector of WCW.
- 1. There are quantum measurements inducing localization in the moduli space of CDs with passive boundary and states at it fixed. In particular, a localization in the moduli characterizing the Lorentz transform of the upper tip of CD would be measured. The measured moduli characterize also the analog of symplectic form in M^4 strongly suggested by twistor lift of TGD - that is the rest system (time axis) and spin quantization axes. Of course, also other kinds of reductions are possible.
- 2. Also a localization to an extension of rationals defining the adeles should occur. Could the value of $n = h_{eff}/h$ be observable? The value of n for given space-time surface at the active boundary of CD could be identified as the order of the smallest Galois group containing all Galois groups assignable to 3-surfaces at the boundary. The superposition of space-time surface would not be eigenstate of n at active boundary unless localization occurs. It is not obvious whether this is consistent with a fixe value of n at passive boundary.

The measured value of n could be larger or smaller than the value of n at the passive boundary of CD but in statistical sense n would increase by the analogy with diffusion on half line defined by non-negative integers. The distance from the origin unavoidably increases in statistical sense. This would imply evolution as increase of maximal value of negentropy and generation of quantum coherence in increasingly longer scales.

3. A further abstract choice corresponds to the replacement of the roles of active and passive boundary of CD changing the arrow of clock time and correspond to a death of self and re-incarnation as time-reversed self.

Can the reductions at the level of WCW reduce to measurements of density matrix?

Can one assume that these measurements reduce to measurements of a density matrix of either entangled system as assumed in the earlier formulation of NMP, or should one allow both options. This question actually applies to all quantum measurements and leads to a fundamental philosophical questions unavoidable in all consciousness theories.

1. Do all measurements involve entanglement between the moduli or extensions of two CDs reduced in the measurement of the density matrix? Non-diagonal entanglement would allow final states states, which are not eigenstates of moduli or of n: this looks strange. This could also lead to an infinite regress since it seems that one must assume endless hierarchy of entangled CDs so that the reduction sequence would proceed from top to bottom. It looks natural to regard single CD as a sub-Universe.

For instance, if a selection of quantization axis of color hypercharge and isospin (localization in the twistor space of CP_2) is involved, one would have an outcome corresponding to a quantum superposition of measurements with different color quantization axis!

Going philosophical, one can also argue, that the measurement of density matrix is only a reaction to environment and does not allow intentional free will.

- 2. Can one assume that a mere localization in the moduli space or for the extension of rationals (producing an eigenstate of n) takes place for a fixed CD a kind of self measurement possible for even unentangled system? If there is entanglement in these degrees of freedom between two systems (say CDs), it would be reduced in these self measurements but the outcome would not be an eigenstate of density matrix. An interpretation as a realization of intention would be approriate.
- 3. If one allows both options, the interpretation would be that state function reduction as a measurement of density matrix is only a reaction to environment and self-measurement represents a realization of intention.
- 4. Self measurements would occur at higher level say as a selection of quantization axis, localization in the moduli space of CD, or selection of extension of rationals. A possible general rule is that measurements at space-time level are reactions as measurements of density matrix whereas a selection of a sector of WCW would be an intentional action. This because formally the quantum states at the level of WCW are as modes of classical WCW spinor field single particle states.

5. If the selections of sectors of WCW at active boundary of CD commute with observables, whose eigenstates appear at passive boundary (briefly *passive observables*) meaning that time reversal commutes with them - they can occur repeatedly during the reduction sequence and self as a generalized Zeno effect makes sense.

If the selections of WCW sectors at active boundary do not commute with passive observables then volition as a choice of sector of WCW must change the arrow of time. Libet's findings show that conscious choice induces neural activity for a fraction of second before the conscious choice. This would imply the correspondences "big" measurement changing the arrow of time - self-measurement at the level of WCW - intentional action and "small" measurement - measurement at space-time level - reaction.

Self as a generalized Zeno effect makes sense only if there are active commuting with passive observables. If the passive observables form a maximal set, the new active observables commuting with them must emerge. The increase of the size of extension of rationals might generate them by expanding the state space so that self would survive only as long at it evolves.

Otherwise there would be only single unitary time evolution followed by a reduction to opposite boundary. This makes sense only if the sequence of "big" reductions for sub-selves can give rise to the time flow experienced by self: the birth and death of mental images would give rise to flow of time of self.

A hierarchical process starting from given CD and proceeding downwards to shorter scales and stopping when the entanglement is stable is highly suggestive and favors self measurements. CDs would be a correlate for self hierarchy. One can say also something about the anatomy and correlates of self hierarchy.

- 1. Self experiences its sub-selves as mental images and even we would represent mental images of some higher level collective self. Everything is conscious but consciousness can be lost or at least it is not possible to have memory about it. The flow of consciousness for a given self could be due to the quantum jump sequences performed by its sub-selves giving rise to mental images.
- 2. By quantum classical correspondence self has also space-time correlates. One can visualize sub-self as a space-time sheet "glued" by topological sum to the space-time sheet of self. Subsystem is not described as a tensor factor as in the standard description of subsystems. Also sub-selves of selves can entangle negentropically and this gives rise to a sharing of mental images about which stereo vision would be basic example. Quite generally, one could speak of stereo consciousness. Also the experiences of sensed presence [J95] could be understood as a sharing of mental images between brain hemispheres, which are not themselves entangled.
- 3. At the level of 8-dimensional embedding space the natural correlate of self would be CD (causal diamond). At the level of space-time the correlate would be space-time sheet or light-like 3-surface. The contents of consciousness of self would be determined by the space-time sheets in the interior of CD. Without further restrictions the experience of self would be essentially four-dimensional. Memories would be like sensory experiences except that they would be about the geometric past and for some reason are not usually colored by sensory qualia. For instance .1 second time scale defining sensory chronon corresponds to the secondary p-adic time scale characterizing the size of electron's CD (Mersenne prime M_{127}), which suggests that Cooper pairs of electrons are essential for the sensory qualia.

The above argument states that the measurements at the level of WCW cannot be regarded as measurements of a density matrix since no second quantization at level of WCW is carried out. About a year after developing this argument I realized that the hierarchy of infinite primes suggests an infinite hierarchy of second quantizations. Could the counterpart for the hierarchy of infinite primes be realized at WCW level automatically? 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 $WCW = WCW \times WCW = ... = WCW^n = ...$

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 $Z^3 = X^3 \cup Y^3 \in WCW$.

Experimental support for the relative arrow of time

It has been found that the arrow of time is relative [D11] (see http://tinyurl.com/yatp6dum). Expressing this in more cautious terms, heat can flow from from system with temperature T_1 to a system with temperature $T_2 > T_1$ if there is correlation between the two systems meaning that the density matrix for the two nuclear systems (samples consisting of hydrogen atoms and carbon atoms) is not mere tensor product of density matrices but contains an additional term describing correlation. It must be emphasized that this finding is not in conflict with the standard view about second law which only says that heat flows from system with higher temperature to that with lower temperature provided that there are no correlations between the systems.

The argument runs as follows. The mutual information for the uncorrelated systems vanishes, and since it can only increase this implies flow of heat in the standard direction. If the mutual information is non-vanishing in the initial situation (due to the correlation) it can also decrease and this can give a heat flow in non-standard direction. This has been observed.

Although one can model the finding using standard thermodynamics, one can ask whether something deeper might be involved. Should one be cautious and talk only about the changing direction of heat flow due to the breaking of the basic assumptions of thermodynamics, and avoid speaking about direction of thermodynamical time? Or could a genuine change of the arrow of time take place? Going even deeper, one must ask what thermodynamical time, the time of physicist (geometric time), and the arrow of time do really mean? What is the relationship between these two times? This leads to ponder questions about the basics of quantum measurement theory and here I can only consider TGD based vision [L77].

1. The basic prediction of zero energy ontology (ZEO) is that the arrow of geometric time can have both signs whereas the arrow of subjective time (relating closely to thermodynamic time) defined by experience created by sequence of state function reductions is always the same. The arrow of geometric time is indeed relative. The flow of geometric time corresponds to the increase of distance between tips of causal diamond (CD) and the increase in particular reduction is at either tip of CD and in this manner defines arrow of time. CD grows either "upwards" or "downwards". A geometric measure for experienced time is that distance between the tips of CD which always increases.

Time reflection symmetry (T) with respect to the center of CD is broken in TGD: the classical time evolutions of space-time surfaces are not T mirror images of each other. This is true also for the quantal evolutions defined by zero energy states essentially as quantum superpositions of classical evolutions. States and their time reversals obey the initial conditions at opposite boundaries of CD. Arrow of time is forced by the place (either boundary of CD), where initial conditions are posed, not by the initial conditions themselves.

- 2. One must however remember that ZEO describes genuine quantum systems whereas thermodynamics decribes ensemble, which is a highly idealized notion. In ZEO arrow of geometric time would change in each "big" quantum jump and would remain the same during the sequence of "small" state function reductions defining the counterpart of Zeno effect or weak measurement.
- 3. Initial conditions breaking the basic assumptions of thermodynamics induce correlations and the heat flow in "wrong" direction in the model for the finding. The arrow of time is claimed to be changed in time interval of length of order 2 millisecond. Interestingly, millisecond happens to characterize the time scale of nerve pulse and ZEO predicts that in living matter the change of the arrow of time takes place routinely. In ZEO based description the growth of the temporal distance between the tips of CD would be of order 2 milliseconds.

It would be however the opposite boundary of CD in geometric past that would receide farther away. One can argue that it is not possible measure the position of the past boundary of CD directly. But is it possible to measure the distance between the tips of CD indirectly from the behavior of the ensemble? ZEO would suggest that the time appearing in the Hamiltonian modelling the system corresponds to the distance between tips of CD and never decreases. The change of the direction of heat flow would correspond to the reduction to the original boundary of CD in the experiment and the correlation would make ZEO visible.

If the two descriptions are equivalent, the initial correlations for the ensemble force should correspond to posing initial conditions at the non-standard boundary of CD leading to the reversal of the arrow of time. The very act of posing the correlations would correspond to a "big" state function reduction to opposite boundary of CD. In standard quantum measurement theory state preparation indeed corresponds to this state function reduction so that the two descriptions might be consistent.

4.3.4 Copenhagen interpretation dead: long live ZEO based quantum measurement theory!

I encountered a very interesting ScienceDaily article "*Physicists can predict the jumps of Schrödinger's cat (and finally save it)*" (see http://tinyurl.com/y51pe2eo). The experimental findings described in the article are extremely interesting from the point of view provide by TGD inspired quantum measurement theory relying on Zero Energy Ontology (ZEO) and provides a test for it.

In standard quantum measurement theory (Copenhagen interpretation) of Bohr quantum jump is random in the sense that it occurs with predictable probabilities to an eigenstate of the measured observables. Their occurrence cannot be predicted and even less prevented - except by monitoring - Zeno effect.

The findings of Minev *et al* are described in the article "*To catch and reverse a quantum jump mid-flight*" [L98] (see https://arxiv.org/abs/1803.00545). The outcome of quantum jump is indeed unpredictable but the time of occurrence is to high degree predictable: there is a detectable warning signal, period of "flight" from the initial to the final state!

A curious feature is that the external signal responsible for the quantum jump can be stopped during the "flight" from the initial to final state. As if the quantum jump is analogous to a domino effect. It is also claimed that the jump can be reversed during flight period by a control signal: if jump has already occurred then one might argue that the control signal induces quantum jump in opposite direction when applied at time which is roughly the mid-time of "flight".

If the findings by Minev *et al* are replicable, one is forced to give up the basic assumption of the standard quantum measurement theory stating that state function reductions occur completely randomly and instantaneously. State function reduction (SR) looks like a continuous, deterministic process. Bohr's theory would be dead also officially and one must finally go back to the blackboard and start serious thinking about fundamentals. It took 92 years - almost a century! State function reduction (SR) is definitely more complex phenomenon than predicted by Bohr.

What is most intriguing that SR looks smooth, deterministic classical time evolution although the outcome is not predictable. People loving hidden variables might be happy but better to think about this more precisely before jumping to any conclusions. Authors apply so called quantum trajectory theory to describe the findings [B18] and report that the model is able to predict the parameters of the parameterization with one per cent accuracy.

Zero energy ontology (ZEO) based view about quantum measurement and the relationship between geometric and subjective time explains why state function reduction looks like a deterministic process. Unfortunately, what ZEO is, is not completely clear [L103]. This allows to consider two options.

1. Both options imply that one can apparently anticipate quantum jump. This could be however an illusion: the observed classical time evolution could occur *after* the quantum jump in opposite direction of time. The fact that the absence of the signal inducing quantum jump does not affect the occurrence of quantum jump suggests that the "flight" period indeed represents the classical evolution after the quantum jump in the reversed direction of time so that the absence of the external signal would not anymore affect the situation. Generalized Zeno effect is essential element ZEO based quantum measurement theory so that SR might be prevented. Perhaps a more plausible interpretation is that the control signal induces the reversal of the quantum jump already occurred. A careful analysis to distinguish between subjective and geometric time and arrows of time for the observer and atom would be needed.

2. The more conventional option nearer to the interpretation of experimenters is that the observered time evolution occurs *before* the quantum jump in standard direction. The period before quantum jump consists of a sequence of "small" state function reductions - "weak" measurements. $M^8 - H$ duality suggests a concrete assignment of the moments of time to them [L103] and there would be also the last moment of this kind. After these things proceed to "big" state function reduction in analogy with domino effect. It is not however obvious why the classical time evolution should appear to converge to the final outcome deterministically.

First ZEO based based view about the findings

What about TGD and zero energy ontology (ZEO) based quantum measurement theory [K85]? Could it explain the revolutionary findings?

- 1. The new element is that quantum states are not time= constant snapshots for time evolution but superpositions of entire deterministic time evolutions at the level of space-time surfaces and at the level of induced spinor fields. SR replaces super position of classical time evolutions with a new one. This like selecting and starting new deterministic computer program. Nondeterminism is in these choices [L77].
- 2. The notion of causal diamond (CD) identified as an intersection of future and past directed light-cones of M^4 with points replaced with CP_2 is crucial. The notion of CD is strongly suggested by the gigantic symmetries of CD essential for the construction of quantum TGD. CD could be seen as embedding space correlate for the perceptive field of a conscious entity self. The upper boundary of CD to be called active boundary A represents the boundary for space-time region from which self can receive classical signals and is therefore natural. The lower boundary, to be called passive boundary B, brings in mind cosmic expansion and follows as a prediction from $M^8 H$ duality.
- 3. There are two kinds of state function reductions in ZEO.
 - (a) In "small" SRs (SSRs) the states change at active boundary of causal diamond (CD) (call it A) but remain unchanged at passive boundary (call it P): generalized Zeno effect occurs at the passive boundary and "weak measurements" (see http://tinyurl.com/zt36hpb) at A. The observables measured commute with those determining the states at P as their eigenstates. In particular, the location of A is measured localizing it and corresponds to the measurement of time as distance between the tips of CD.

"Big" SRs (BSRs) reverse the arrow of time of zero energy states and the roles of A and P. BSR is preceded by a sequence of SSRs - "weak" or almost classical measurements. In TGD inspired theory of consciousness [L77, L103] [K67] this sequence defines the life cycle of a conscious entity - self.

What is of crucial importance that BSR creates the illusion that it is an outcome of a continuous process: this realizes quantum classical correspondence (QCC). Standard observer assumes standard arrow of time and the space-time surfaces in the final time reversed state seem to lead to the 3-surface serving as a correlate for the final state! As if BSR would be outcome of a smooth deterministic process, which it is not! There is actually a superposition of these 3-surfaces at A after BSR but in the resolution used this is not detected. Putting it more precisely:

- 1. The time reversal of time evolution is in good approximation obtained by time reflection symmetry T but not quite since T is slightly broken. This is extremely small effect.
- 2. Before BSR one has a distribution of 3-surfaces X^3 defining the ends of space-time surfaces X^4 at A: 3-surfaces X^3 corresponds to different outcomes of BSR and can differ dramatically. Observer is not conscious of this. This is like a situation of Schrödinger cat before measurement: it is impossible to be conscious about the superposition of dead and alive cat.

After BSR one has quantum superposition of space-time surfaces directed to geometric past. Near the end of space-time at A they look like leading to a unique classical counterpart of final state of state function reduction. As if the state function reduction were a smooth, continuous, deterministic process. BSR guarantees this but BSR is not a smooth evolution.

The experimental findings could be understood by applying this general picture.

- 1. One can assign to the evolution from initial state G of atom at P to final state E at A a sequence of small reductions, weak measurements and also superposition of classical time evolutions approximated by single evolution in given measurement resolution. The state E is superposition of various measurement outcomes and each of them corresponds to a superposition of space-time surfaces identical in the measurement resolution used.
- 2. Then occurs the BSR: atom jumps from state E to state D. This selects from the superposition of space-time surfaces/time only the evolutions apparently leading to D. Or more precisely: the superposition of reversed time evolutions starting from D at A and very similar near A but deviating farther from it. The illusion about continuous, smooth, deterministic time evolution from G to D is created!
- 3. Also the possibility to anticipate the reduction would be an illusion due to the different arrows of time for observer and the observed system after BSR. The time reversed time evolution actually starts from the final state. The warning signal (absence of photon emission would be natural consequence of the reduction but in reversed arrow of time. The illusion would be due to the identification of arrows of time of observer and the atom that made state function reduction. This conforms with the observation that one can drop away the periodic signal inducing the quantum jumps during the "flight" period identified as the deterministic process representing the quantum jump.

The lesson would be that one must always check whether the arrow of time for the target of attention is same as my own. Not a good idea to be on the wrong lane (means death also in ZEO based consciousness theory).

It is also claimed that on can prevent the quantum jump using a signal during the "flight" period. Generalized Zeno effect is basic element of TGD but the signal forcing the state to remain in P would be present before the quantum jump. This would suggest that the control signal induced quantum jump in opposite direction. To really understand the situation a careful analysis of the relationships between subjective and geometric times of observer and between geometric time of observer and atomic system after and before the quantum jump would be needed.

Also Libet's findings about active aspects of consciousness [J15] can be interpreted in ZEO along the same lines. The observation that the neural activity begins before conscious decision can be understood by saying that the act of free will as a big state function reduction changed the arrow of time for an appropriate subsystem of the system studied. Tte time reversed classical evolutions from the outcome of the volitional action were interpreted erratically as a time evolution leading to the conscious decision. A less precise manner to say this is that conscious decision (big state function reduction) sent a classical signal to geometric past with opposite arrow of time initiating neural activity. Libet's finding led physicalistic neuroscientists to conclude that free will is an illusion. The actual illusions were physicalism and the belief that arrow of time is always the same.

To sum up, ZEO is fantastic magician. Maybe this magic is necessary for the mental health of observer: a world without this illusion would be like nightmare where one cannot trust anything.

Second ZEO based based view about the findings inspired by $M^8 - H$ duality

I have learned to take experimental findings very seriously and I am ready to aks whether the above described option the only possibility allowed by ZEO or can one think other alternatives? It would be nice to answer "No" but one can consider variants of ZEO [L103] inspired by so called $M^8 - H$ duality [L66, L117].

The sequence of "small" state function reductions (SSRs) should have the last one. Is the "big" state function reduction (BSR) forced by some condition? One idea is that the life cycle of self corresponds to a measurement of all observables assignable to the active boundary A of CD and commuting with those defining the unaffected states at passive boundary P are measured (time as a location of A belongs to these observables measured in each SSR).

I have discussed in [L103] possible modifications of ZEO inspired by so called $M^8 - H$ duality [L66, L117]. One motivation is that time flow as shifting M^4 time t = constant hyper-plane can be argued to be more natural than that for light-cone boundary. Light-cone boundaries are however favored by its huge symmetries essential for the definition of the geometry of "world of classical worlds" (WCW). $M^8 - H$ duality forces passive light-cone boundary P and the identification of A as boundary of region where sensory signals can arrive to self is natural.

 $M^8 - H$ duality allows to consider variants the original ZEO.

1. $M^8 - H$ duality

Let us first briefly summarize what $M^8 - H$ duality [L66] is.

- 1. $M^8 H$ duality is one of the key ideas of TGD, and states that one can regard space-times as surfaces in either complexified octonionic M^8 or in $M^4 \times CP_2$. The dynamics M^8 is purely algebraic and requires that either tangent or normal space of space-time surface is associative (quaternionic).
- 2. The algebraic equations for space-time surfaces in M^8 state the vanishing of either the real or imaginary part (defined in quaternionic sense) for octonion valued polynomial P(o) with real coefficients. Besides 4-D roots one obtains as universal exceptional roots 6-spheres at boundary of the light-cone of M^8 with radii given by the roots r_n of the polynomial in question. They correspond to the balls $t = r_n$ (t is octonionic real coordinate) inside Minkowski light-cone with each point have as fiber a 3-sphere S^3 with radius contracting to zero at the boundary of the light-cone of M^4 . These 6-spheres are clearly analogous to branes connected by 4-D space-time surfaces.
- 3. The intersections of space-time surfaces with 6-spheres would be 2-D and I have interpreted them as partonic 2-surfaces identifiable as topological particle reaction vertices partonic 2-surfaces at which incoming and outgoing light-like 3-surfaces meet along their ends. These light-like 3-surfaces partonic orbits would represent the boundaries between space-time regions with Euclidian and Minkowskian signatures of the induced metric. Partonic 2-surfaces would be analogs of the vertices of Feynman diagrams. The boundaries of string world sheets predicted as singularities of minimal surfaces defining space-time surfaces would be along the partonic orbits and give rise to QFT type description using cognitive representations and analogs of twistor diagrams consisting of lines.

2. $M^8 - H$ duality and consciousness

One can ask whether $M^8 - H$ duality and this braney picture has implications for ZEO based theory of consciousness. Certain aspects of $M^8 - H$ duality indeed challenge the recent view about consciousness based on ZEO (zero energy ontology) and ZEO itself.

- 1. The moments $t = r_n$ defining the 6-branes correspond classically to special moments for which phase transition like phenomena occur. Could $t = r_n$ have a special role in consciousness theory?
 - (a) For some SSRs the increase of the size of CD reveals new $t = r_n$ plane inside CD. One can argue that these SSRS define very special events in the life of self. This would not modify the original ZEO considerably but could give a classical signature for how many ver special moments of consciousness have occurred: the number of the roots of P would be a measure for the lifetime of self and there would be the largest root after which BSR would occur.
 - (b) Second possibility is more radical. One could one think of replacing CD with single truncated future- or past-directed light-cone containing the 6-D universal roots of P up

to some r_n defining the upper boundary of the truncated cone? Could $t = r_n$ define a sequence of moments of consciousness? To me it looks more natural to assume that they are associated with very special moments of consciousness.

2. For both options SSRs increase the number of roots r_n inside CD/truncated light-one gradually and thus its size? When all roots of P(o) would have been measured - meaning that the largest value r_{max} of r_n is reached -, BSR would be unavoidable.

BSR could replace P(o) with $P_1(r_1 - o)$: r_1 must be real and one should have $r_1 > r_{max}$. The new CD/truncated light-cone would be in opposite direction and time evolution would be reversed. Note that the new CD could have much smaller size size if it contains only the smallest root r_0 . One important modification of ZEO becomes indeed possible. The size of CD after BSR could be much smaller than before it. This would mean that the re-incarnated self would have "childhood" rather than beginning its life at the age of previous self - kind of fresh start wiping the slate clean.

One can consider also a less radical BSR preserving the arrow of time and replacing the polynomial with a new one, say a polynomial having higher degree (certainly in statistical sense so that algebraic complexity would increase).

3. Is a more conservative view possible?

Could this picture allow to build a more conservative picture more akin to that proposed by experimenters?

- 1. The interpretation of the detected time evolution as that *before* the quantum jump would conform with the interpretation of experimentalists that a kind of domino effect is involved and also with the observation that stopping the signal causing the quantum jumps does not anymore affect the situation.
- 2. It is however unclear how to understand why the evolution looks like leading to the outcome unless the sequence of r_n :s defines a sequence of steps gradually taking the system near the final state.
- 3. What about preventing the BSR by external signal and even reversing the quantum jump? This would require an external perturbation of the octonionic polynomial increasing the value of the largest root r_{max} or even the degree of the polynomial and bringing in additional significant moments of life. Is it possible to speak about external perturbations of the coefficients of polynomials assumed to be rational numbers? The perturbations would come from a higher level in the hierarchy of selves (experimentalist), and one can imagine them in the framework of many-sheeted space-time.

To sum up, to my opinion (which could change) the first option looks more plausible. The introduction of moments $t = r_n$ as special moments in the life of self looks highly attractive and also the possibility of wiping the slate clear.

4.4 Negentropy Maximization Principle

Negentropy Maximization Principle (NMP [K80]) stating that the reduction of entanglement entropy is maximal at a given step of state function reduction process following U-process is the basic variational principle for TGD inspired theory of consciousness and says that the information contents of conscious experience is maximal. Although this principle is diametrically opposite to the second law of thermodynamics it is structurally similar to the second law. NMP does not dictate the dynamics completely since in state function reduction any eigen state of the density matrix is allowed as final state. NMP need not be in contradiction with second law of thermodynamics which might relate as much to the ageing of mental images as to physical reality.

4.4.1 Basic Form Of NMP

Negentropy Maximization Principle (NMP) in its original form codes for the basic rules of the standard state function reduction and implies that system ends up to an eigenstate of the density matrix identified as observable. In TGD framework must ask whether NMP should be restricted only to the entanglement between zero modes of WCW representing classical degrees of freedom and quantum fluctuating degrees of freedom or generalize it to apply to any pair of subsystems so that state function reduction sequence could be regarded as a sequence of self measurements. I have chosen the latter option as a working hypothesis.

NMP that the state function reduction process following U-process gives rise to a maximal reduction of entanglement entropy at each step of the process. State function process could proceed at the level of all CDs. It is not clear whether one can assign any geometric time duration to this process or whether there is any need for this. If the subsystem allows entangled pairs of free systems (no binding energy) there is more or less unique pair with the maximal entanglement entropy and NMP therefore implies a decomposition to a unique pair of unentangled systems. The process repeats itself for these systems and stops when the resulting subsystem cannot be decomposed to a pair of free systems since energy conservation makes the reduction of entanglement kinematically impossible in the case of bound states. Number theoretic entanglement entropies mean an important modification of this picture.

4.4.2 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. It's 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.

Do positively colored emotions allow a representation of Boolean logic?

Weak form of NMP allows the state function reduction to occur in $2^n - 1$ ways corresponding to subspaces of the sub-space defined by n-dimensional projector if the density matrix is n-dimensional projector (the outcome corresponding to 0-dimensional subspace and is excluded). If the probability for the outcome of state function reduction is same for all values of the dimension $1 \le m \le n$, the probability distribution for outcome is given by binomial distribution B(n, p) for p = 1/2 (head and tail are equally probable) and given by $p(m) = b(n,m) \times 2^{-n} = (n!/m!(n-m)!) \times 2^{-n}$. This gives for the average dimesion E(m) = n/2 so that the negentropy would increase on the average. The world would become gradually better. Note that one assumes that there is some preferred basis for the states and these numbers apply when this basis is given.

One cannot avoid the idea that these different degrees of negentropic entanglement could actually give a realization of Boolean algebra in terms of conscious experiences.

- 1. There should be a mapping of k-dimensional subspaces of n-dimensional space to the fermionic representation of Boolean algebra
- 2. Could one speak about a hierarchies of codes of cognition based on the assignment of different degrees of "feeling good" to the Boolean statements? If one assumes that the *n*:th bit is always 1, all independent statements except one correspond at least two non-vanishing bits and corresponds to negentropic entanglement. Only of statement (only last bit equal to 1) would correspond 1 bit and to state function reduction reducing the entanglement completely (brings in mind the fruit in the tree of Good and Bad Knowlege!).
- 3. A given hierarchy of breakings of super-symplectic symmetry corresponds to a hierarchy of integers $n_{i+1} = \prod_{k \leq i} m_k$. The codons of the first code would consist of sequences of m_1 bits. The codons of the second code consists of m_2 codons of the first code and so on. One would have a hierarchy in which codons of previous level become the letters of the code words at the next level of the hierarchy.

In fact, I ended up with almost Boolean algebra for decades ago when considering the hierarchy of genetic codes suggested by the hierarchy of Mersenne primes $M(n + 1) = M_{M(n)}$, $M_n = 2^n - 1$.

1. The hierarchy starting from $M_2 = 3$ contains the Mersenne primes $3, 7, 127, 2^{127} - 1$ and Hilbert conjectured that all these integers are primes. These numbers are almost dimensions

of Boolean algebras with n = 2, 3, 7, 127 bits. The maximal Boolean sub-algebras have m = n - 1 = 1, 2, 6, 126 bits.

- 2. The observation that m = 6 gives 64 elements led to the proposal that it corresponds to a Boolean algebraic assignable to genetic code and that the sub-algebra represents maximal number of independent statements defining analogs of axioms. The remaining elements would correspond to negations of these statements. I also proposed that the Boolean algebra with $m = 126 = 6 \times 21$ bits (21 pieces consisting of 6 bits) corresponds to what I called memetic code obviously realizable as sequences of 21 DNA codons with stop codons included. Emotions and information are closely related and peptides are regarded as both information molecules and molecules of emotion.
- 3. This hierarchy of codes would have the additional property that the Boolean algebra at n + 1:th level can be regarded as the set of statements about statements of the previous level. One would have a hierarchy representing thoughts about thoughts about.... It should be emphasized that there is no need to assume that the Hilbert's conjecture is true.

One can obtain this kind of hierarchies as hierarchies with dimensions $m, 2^m, 2^{2^m}, ...$ that is $n(i+1) = 2^{n(i)}$. The conditions that n(i) divides n(i+1) is non-trivial only for at the lowest step and implies that m is power of 2 so that the hierarchies starting from $m = 2^k$. This is natural since Boolean algebras are involved. If n corresponds to the size scale of CD, it would come as a power of 2.

p-Adic length scale hypothesis has also led to this conjecture. A related conjecture is that the sizes of CDs correspond to secondary p-adic length scales which indeed come as powers of two. In case of electron this predicts that the minimal size of CD associated with electron corresponds to time scale T = .1 seconds, the fundamental time scale in living matter (10 Hz is the fundamental biorhythm). It seems that the basic hypothesis of TGD inspired partly by the study of elementary particle mass spectrum and basic bio-scales (there are 4 p-adic length scales defined by Gaussian Mersenne primes in the range between cell membrane thickness 10 nmandsize 2.5 μ m of cell nucleus!) follow from the proposed connection between emotions and Boolean cognition.

Hilbert's conjecture relates in interesting manner to space-time dimension. Suppose that Hilbert's conjecture fails and only the four lowest Mersenne integers in the hierarchy are Mersenne primes that is $3, 7, 127, 2^{127} - 1$. In TGD one has hierarchy of dimensions associated with space-time surface coming as 0, 1, 2, 4 plus embedding space dimension 8. The abstraction hierarchy associated with space-time dimensions would correspond discretization of partonic 2-surfaces as point set, discretization of 3-surfaces as a set of strings connecting partonic 2-surfaces characterized by discrete parameters, discretization of space-time surfaces as a collection of string world sheet with discretized parameters, and maybe - discretization of embedding space by a collection of space-time surfaces. Discretization means that the parameters in question are algebraic numbers in an extension of rationals associated with p-adic numbers.

In TGD framework it is clear why embedding space cannot be higher-dimensional and why the hierarchy does not continue. Could there be a deeper connection between these two hierarchies. For instance, could it be that higher dimensional manifolds of dimension $2 \times n$ can be represented physically only as unions of say n 2-D partonic 2-surfaces (just like $3 \times N$ dimensional space can be represented as configuration space of N point-like particles)? Also infinite primes define a hierarchy of abstractions. Could it be that one has also now similar restriction so that the hierarchy would have only finite number of levels, say four. Note that the notion of n-group and n-algebra involves an analogous abstraction hierarchy.

4.4.3 Can One Define Measures For The Information Contents Of Mental Image?

Despite the fact that one cannot write formula for the contents of conscious experience, one can define information measures for conscious experience as differences of the information measures for the initial and final quantum histories. Negentropy gain is the most natural information measure of this kind. For instance, the sum of the net entanglement negentropy gains over the steps of the self measurement cascade could define a quantity characterizing net information gain for a single moment of consciousness at each step.

One could also information measure to selves as the entanglement negentropy after the state function reduction process has ended. This would assign to each subsystem stable under NMP a negentropy. For bound state entanglement this information would be negative but for negentropic entanglement it would be positive. One can ask whether the hypothesis that this information increases during quantum jump sequence is equivalent with NMP. In the case of entire Universe the application of this principle becomes problematic.

Entropy gradients with respect to subjective time could be used to characterize how the information gain of conscious experience of self changes. These gradients approach zero when self approaches thermal equilibrium. In TGD framework entropy gradients correlate with emotions, which means a somewhat counter intuitive connection between emotions and information gain or loss (consistent however with the fact that peptides are both informational molecules and molecules of emotion [J22]). Note that the binding of information molecules to receptors means the formation larger bound states accompanied by the experience of oneness at molecular level (are sex and spiritual experiences present already at the molecular level?) and macro temporal quantum coherence so that quantum computer like operations might become possible.

Life as islands of rational/algebraic numbers in the seas of real and p-adic continua?

Rational and even algebraic entanglement coefficients make sense in the intersection of real and p-adic words, which suggests that life and conscious intelligence reside in the intersection of the real and p-adic worlds. This would mean that the mathematical expressions for the space-time surfaces (or at least 3-surfaces or partonic 2-surfaces and their 4-D tangent planes) make sense in both real and p-adic sense for some primes p. Same would apply to the expressions defining quantum states. In particular, entanglement probabilities would be rationals or algebraic numbers so that entanglement can be negentropic and the formation of bound states in the intersection of real and p-adic worlds generates information and is thus favored by NMP.

1. For the minimal option life would be also 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 only the data from rational and some algebraic points of the partonic 2-surface dictate U-matrix. This means discretization at parton level and something which might be called number theoretic quantum field theory should emerge as a description of intentional action.

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 [K6]. Livingdead 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 [K108].

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 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.

4.4.4 Hyper-Finite Factors Of Type II₁ And NMP

Hyper-finite factors of type II₁ bring in additional delicacies to NMP. The basic implication of finite measurement resolution characterized by Jones inclusion is that state function reduction can never reduce entanglement completely so that entire universe can be regarded as an infinite living organism. It would seem that entanglement coefficients become \mathcal{N} valued and the same is true for eigen states of density matrix. For quantum spinors associated with \mathcal{M}/\mathcal{N} entanglement probabilities must be defined as traces of the operators \mathcal{N} . An open question is whether entanglement probabilities defined in this manner are algebraic numbers always (as required by the notion of number theoretic entanglement entropy) or only in special cases.

4.4.5 $M^8 - H$ duality and consciousness

 $M^8 - H$ duality is one of the key ideas of TGD and one can ask whether it has implications for TGD inspired theory of consciousness and it indeed forces to challenge the recent ZEO based view about consciousness [L77].

Objections against ZEO based theory of consciousness

Consider first objections against ZEO based view about consciousness.

1. ZEO (zero energy ontology) based view about conscious entity can be regarded as a sequence of "small" state function reductions (SSRs) identifiable as analogs of so called weak measurements at the active boundary of causal diamond (CD) receding reduction by reduction farther away from the passive boundary, which is unchanged as also the members of state pairs at it. One can say that weak measurements commute with the observables, whose eigenstates the states at passive boundary are. This asymmetry assigns arrow of time to the self having CD as embedding space correlate. "Big" state function reductions (BSRs) would change the roles of boundaries of CD and the arrow of time. The interpretation is as death and re-incarnation of the conscious entity with opposite arrow of time.

The question is whether quantum classical correspondence (QCC) could allow to say something about the time intervals between subsequent values of temporal distance between weak state function reductions.

- 2. The questionable aspect of this view is that $t_M = constant$ sections look intuitively more natural as seats of quantum states than light-cone boundaries forming part of CD boundaries. The boundaries of CD are however favoured by the huge symplectic symmetries assignable to the boundary of M^4 light-cone with points replaced with CP_2 at level of H. These symmetries are crucial or the existence of the geometry of WCW ("world of classical worlds").
- 3. Second objection is that the size of CD increases steadily: this nice from the point of view of cosmology but the idea that CD as correlate for a conscious entity increases from CP_2 size to cosmological scales looks rather weird. For instance, the average energy of the state assignable to either boundary of CD would increase. Since zero energy state is a superposition of states with different energies classical conservation law for energy does not prevent this [L114]: essentially quantal effect due to the fact that the zero energy states are not exact eigenstates of energy could be in question. In BSRs the energy would gradually increase. Admittedly this looks strange and one must be keen for finding more conventional options.

4. Third objection is that re-incarnated self would not have any "childhood" since CD would increase all the time.

One can ask whether $M^8 - H$ duality and this braney picture has implications for ZEO based theory of consciousness. Certain aspects of $M^8 - H$ duality indeed challenge the recent view about consciousness based on ZEO (zero energy ontology) and ZEO itself.

- 1. The moments $t = r_n$ defining the 6-branes correspond classically to special moments for which phase transition like phenomena occur. Could $t = r_n$ have a special role in consciousness theory?
 - (a) For some SSRs the increase of the size of CD reveals new $t = r_n$ plane inside CD. One can argue that these SSRS define very special events in the life of self. This would not modify the original ZEO considerably but could give a classical signature for how many ver special moments of consciousness have occurred: the number of the roots of P would be a measure for the lifetime of self and there would be the largest root after which BSR would occur.
 - (b) Second possibility is more radical. One could one think of replacing CD with single truncated future- or past-directed light-cone containing the 6-D universal roots of P up to some r_n defining the upper boundary of the truncated cone? Could $t = r_n$ define a sequence of moments of consciousness? To me it looks more natural to assume that they are associated with very special moments of consciousness.
- 2. For both options SSRs increase the number of roots r_n inside CD/truncated light-one gradually and thus its size? When all roots of P(o) would have been measured - meaning that the largest value r_{max} of r_n is reached -, BSR would be unavoidable.

BSR could replace P(o) with $P_1(r_1 - o)$: r_1 must be real and one should have $r_1 > r_{max}$. The new CD/truncated light-cone would be in opposite direction and time evolution would be reversed. Note that the new CD could have much smaller size size if it contains only the smallest root r_0 . One important modification of ZEO becomes indeed possible. The size of CD after BSR could be much smaller than before it. This would mean that the re-incarnated self would have "childhood" rather than beginning its life at the age of previous self - kind of fresh start wiping the slate clean.

One can consider also a less radical BSR preserving the arrow of time and replacing the polynomial with a new one, say a polynomial having higher degree (certainly in statistical sense so that algebraic complexity would increase).

Could one give up the notion of CD?

A possible alternative view could be that one the boundaries of CD are replaced by a pair of two $t = r_N$ snapshots $t = r_0$ and $t = r_N$. Or at least that these surfaces somehow serve as correlates for mental images. The theory might allow reformulation also in this case, and I have actually used this formulation in popular lectures since it is easier to understand by laymen.

1. Single truncated light-cone, whose size would increase in each SSR would be present now since the spheres correspond to balls of radius r_n at times r_n . If $r_0 = 0$, which is the case for $P(o) \propto o$, the tip of the light-cone boundary is one root. One cannot avoid association with big bang cosmology. For $P(0) \neq r_0$ the first conscious moment of the cosmology corresponds to $t = r_0$. One can wonder whether the emergence of consciousness in various scales could be described in terms of the varying value of the smallest root r_0 of P(o).

If one allows BSR:s this picture differs from the earlier one in that CDs are replaced with alternation of light-cones with opposite directions and their intersections would define CD.

2. For this option the preferred values of t for SSRs would naturally correspond to the roots of the polynomial defining $X^4 \subset M^8$. Moments of consciousness as state function reductions would be due to collisions of 4-D space-time surfaces X^4 with 6-D branes! They would replace the sequence of scaled CD sizes. CD could be replaced with light-one and with the increasing sequence $(r_0, ..., r_n)$ of roots defining the ticks of clock and having positive and negative energy states at the boundaries r_0 and r_n .

3. What could be the interpretation for BSRs representing death of a conscious entity in the new variant of ZEO? Why the arrow of time would change? Could it be because there are no further roots of P(o)? The number of roots of P(o) would give the number of small state function reductions?

What would happen to P(o) in BSR? The vision about algebraic evolution as increase of the dimension for the extension of rationals would suggest that the degree of P(o) increases as also the number of roots if all complex roots are allowed. Could the evolution continue in the same direction or would it start to shift the part of boundary corresponding to the lowest root in opposite direction of time. Now one would have more roots and more algebraic complexity so that evolutionary step would occur.

In the time reversal one would have naturally $t_{max} \ge r_{n_{max}}$ for the new polynomial $P(t-t_{max})$ having $r_{n_{max}}$ as its smallest root. The light-cone in M^8 with tip at $t = t_{max}$ would be in opposite direction now and also the slices $t - t_{max} = r'_n$ would increase in opposite direction! One would have two light-cones with opposite directions and the $t = r_n$ sections would replace boundaries of CDs. The reborn conscious entity would start from the lowest root so that also it would experience childhood.

This option could solve the argued problems of the previous scenario and give concrete connection with the classical physics in accordance with QCC. On the other hand, a minimal modification of original scenario combined with $M^8 - H$ duality with moments $t = r_n$ as special moments in the life of conscious entity allows also to solve these problems if the active boundary of CD is interpreted as boundary beyond which classical signals cannot contribute to perceptions.

What could be the minimal modification of ZEO based view about consciousness?

What would be the minimal modification of the earlier picture? Could one *assume* that CDs serve as embedding space correlates for the perceptive field?

- 1. Zero energy states would be defined as before that is in terms of 3-surfaces at boundaries of CD: this would allow a realization of huge symmetries of WCW and the active boundary A of CD would define the boundary of the region from which self can receive classical information about environment. The passive boundary P of CD would define the boundary of the region providing classical information about the state of self. Also now BSR would mean death and reincarnation with an opposite arrow of time. Now however CD would shrink in BSR before starting to grow in opposite time direction. Conscious entity would have "childhood".
- 2. If the geometry of CD were fixed, the size scale of the $t = r_n$ balls of M^4 would first increase and then start to decrease and contract to a point eventually at the tip of CD. One must however remember that the size of $t = r_n$ planes increases all the time as also the size of CD in the sequences of SSRs. Moments $t = r_n$ could represent special moments in the life of conscious entity taking place in SSRs in which $t = r_n$ hyperplane emerges inside CD with increased size. The recent surprising findings challenging the Bohrian view about quantum jumps [L98] can be understood in this picture [L98].
- 3. $t = r_n$ planes could also serve as correlates for memories. As CD increases at active boundary new events as $t = r_n$ planes would take place and give rise to memories. The states at $t = r_n$ planes are analogous to seats of boundary conditions in strong holography and the states at these planes might change in state function reductions - this would conform with the observations that our memories are not absolute.

To sum up, the original view about ZEO seems to be essentially correct. The introduction of moments $t = r_n$ as special moments in the life of self looks highly attractive as also the possibility of wiping the slate clear by reduction of the size of CD in BSR.

4.5 Some comments related to Zero Energy Ontology (ZEO)

Zero energy ontology (ZEO) lies behind TGD based quantum measurement theory in turn giving rise to a theory of consciousness by making observed part of system as a conscious entity - self [L77]. ZEO solves the basic paradox of quantum measurement theory forcing to give up ontology altogether in the Copenhagen interpretation. ZEO has become a key aspect of the entire TGD based physics.

The basic prediction of ZEO is that ordinary ("big") state function reductions (BSFRs) involve change of the arrow of time. There is a lot of support for this prediction. The recent highly counterintuitive findings of Minev *et al* provided support for the time reversal in atomic systems [L98] [L98]. Fantappie [J82] proposed decades ago time reversal in living systems and introduced syntropy as time reversed entropy. In living matter the generation of more complex molecules from their building bricks can be seen as decay in time reversed direction. Phase conjugate laser beams are known to obey time reversed second law.

Also Libet's findings [J15] related to the active aspects of conscious experience find a nice explanation in terms of the time reversal. The latest application is to the understanding of the mysterious looking findings about earthquakes and volcanic eruptions suggesting that macroscopic quantum jumps involving time reversal are in question [L101]. This suggest that experimental verification of the time reversal and occurrence of macroscopic quantum jumps is possible by studying causal anomalies. For these reasons is important to try to develop the details of the view about ZEO as precise as possible.

In the sequel I will consider more precise mathematical formulation and physical interpretation of ZEO. ZEO forms also the cornerstone of TGD inspired theory of consciousness and quantum biology and I will consider also some related aspects of ZEO such as the notions of free will and intentionality, the notions of memory and precognition as its time reversal, intuitive in contrast to formal reasoning, and remote metabolism as a universal thermodynamical mechanism of metabolism in ZEO based thermodynamics.

4.5.1 General view about ZEO

The details of ZEO - in particular the technical details related to the conservation laws BSFR and SSFR - are from well-understood and the following is an attempt to fix these details by using analogy with cosmology.

Rough view about ZEO

Consider first what ZEO roughly means.

- 1. The realization of ZEO [L116, L77, L87, L111] involves besides the notions of "small" (SSFR) and "big" state function reduction (BSFR) also the notion of causal diamond (CD). CD defines perceptive field of conscious entity as a 8-D region $cd \times CP_2$, where cd is the 4-D causal diamond of M^4 defined as the intersection of future and past directed light-cones.
- 2. At the classical level the basic entity is space-time surface connecting 3-surfaces at the opposite boundaries of CD. The space-time surfaces inside sub-CD continue outside and there is a hierarchy of CDs with largest CD beyond which space-time surfaces do not continue. This defines a space-time correlate for the hierarchy of selves.

Space-time surfaces are preferred extremals of the basic action principle defined by the twistor lift of TGD [L96]. Minimal surfaces with 2-D string world sheets as singularities would be in question. They connect 3-surfaces at the boundaries of CD and are analogous to Bohr orbits so that not any pair is possible and the conditions characterizing preferred extremal property might even imply 1-1 correspondence between these 3-surfaces.

3. Zero energy states are superpositions of preferred extremals. One can also understand zero energy states as superpositions of deterministic programs - quantum programs, functions in the sense of quantum biology, or quantum behaviors. ZEO allows to solve the basic paradox of quantum measurement theory since the non-determinism of quantum jump between zero energy states corresponds to the causality of free will and is not in conflict with the classical determinism realizing the causality of field equations. Experienced time and geometric time are not same but there is a strong correlation between them.

- 4. In SSFRs the active boundary of CD shifts to future at least in statistical sense. This is preceded by a unitary time evolution generating superposition of CDs with different sizes but having fixed passive boundary and same superposition of 3-surfaces at it. SSFR involves time-localization to single CD with fixed temporal distance between its tips. Essentially time measurement is in question.
- 5. In BSFR the arrow of time changes and one can say that state function reduction measuring set of observables takes place at the active boundary of CD, which becomes a passive boundary at which state does not change during subsequent SSFRs in which CD increases in opposite direction with the former passive boundary becoming an active boundary. The change of the arrow of time in BSFR creates the illusion that instantaneous quantum jump corresponds to a smooth and deterministic time evolution leading to the final state [L98] [L98].

The mathematical and physical details of the picture are not completely nailed down, and the best manner to proceed is to return to basic questions again and again and to challenge the details of the existing picture. In the following I will do my best to invent nasty arguments against ZEO.

ZEO and conservation laws

The geometry of CD breaks Poincare invariance. Lorentz invariance with respect to the either tip of CD is exact symmetry and is extremely attractive in the construction of members of state pairs in ZEO. Classically Poincare invariance is exact and one can deduce expressions for conserved quantities for both bosonic and fermionic sector: the latter have interpretation as operators, whose eigenvalues in Cartan algebra are by quantum classical correspondence (QCC) identified as classical values of conserved quantities.

ZEO involves the somewhat questionable assumption that one can assign well-defined Poincare quantum numbers to both boundaries and that these quantum numbers are opposite: this motivates the term ZEO.

- 1. $M^8 H$ duality [L106] allows to assign to CDs with either boundary fixed a moduli space, which corresponds to Poincare group. The proposal is that Poincare invariance is realized at this level and that the values of conserved charges in Cartan algebra correspond to the Poincare quantum numbers labelling these wave functions. The wave functions at the boundaries of CD could be arranged in representations of Lorentz group acting as exact symmetry of the boundary.
- 2. There is further little nuisance involved. Only time translations, which correspond to a nonnegative time value as distance from the fixed boundary of CD are possible. One would obtain momentum eigenstates restricted to a future or past light-cone. This is of course what happens in TGD based cosmology. Maybe one must just accept this as a physical fact forcing to give up mathematical idealization.

Formally one would replace the plane wave basis with a basis multiplied by characteristic function for future or past light-cone equal to 1 inside the light-cone and vanishing elsewhere. This basis is closed with respect to summation. This would mean that the states are not anymore exact eigenstates of momentum globally but superposition of Lorentz boosts of the basic momentum obtained by Fourier expanding the characteristic function of future/past light-cone.

But what about CD which is intersection of future and past directed light-cones? Can one really assign to both boundaries wave functions defined in entire future (or past) directed light-cone? It seems that this is the case. Zero energy state would be entangled state as a superposition of products of boosted momentum eigenstates with opposite momenta representing the characteristic function of CD.

The usual idea about unitary time evolution for Schrödinger amplitude would be given up inside CD, and replaced by a sequence of unitary time evolutions producing de-localization of the active boundary of CD and followed by a localization.

3. There is still a problem. A complete de-localization for the boundaries of CD is not consistent with the intuitive idea that CD has definite size scale. In wave mechanics the plane waves are only idealizations and in the real world one replaces plane waves with wave packets. Gaussian wave packets have the nice feature that they remain Gaussian in Fourier transformation.

If one has Gaussian wave packet for the temporal distance between the tips of CD concentrated on certain value of time, the Fourier transform for this is Gaussian wave packet concentrated around certain relative energy, which is two times the energy assignable to say passive boundary of CD. Instead of sharp value of time as distance between the tips of CD one would have Gaussian distribution for its value. This is consistent with Lorentz invariance since zero energy states allow superposition over states with varying momenta assignable to say active boundary. The wave function would be essentially Gaussian in energy in the rest system and one can consider also wave functions in Lorentz group leaving the passive boundary of CD invariant.

SSFRs in ZEO

In the proposed picture the sequence of SSFRs could mean gradual widening of the Gaussian wave packet for the value of measured time as the temporal distance between the tips of CD by discrete steps.

The basic condition is that the states at passive boundary of CD identified as superpositions of 3-surfaces remain unaffected during the sequences of SSFRs increasing the size of CD. This corresponds to generalized Zeno effect and in consciousness theory thr unchanging part of zero energy state corresponds to unchanging part of self, one might call it soul. One can imagine two options.

Option I: CD increases statistically in SSFRs but classical energy is conserved for spacetime surfaces connecting its boundaries. Energy density would decreases as CD increases. This does not seem too bad actually: it would be analogous to matter dominated cosmology.

Not only superpositions of 3-surfaces at passive boundary of CD would be conserved but also their 4-D tangent spaces would be unaffected: this is unnecessarily strong a condition for generalized Zeno effect.

Option II: CD increases but classical energies decrease. This looks more plausible- if not the only - option and is strongly favoured by the analogy of CD with expanding cosmology. It also conforms with uncertainty principle. The process would be essentially quantum analog of cooling or analog for what happens for particle in a box expanding adiabatially. The classical energies of the space-time surfaces in zero energy state would thus decrease as CD increases.

Also this option allows the states as superpositions of 3-surfaces to at passive boundary of CD to remain unffected in expansion of CD. The classical energies can however decrease because the space-time surfaces - tangent spaces of space-time surfaces at passive boundary - can change so that also energies can change.

This option is completely analogous to quantum adiabatic change in which the coefficients in the superposition of energy eigenstates are unaffected but energies change.

Option II looks more natural and will be considered in more detail.

- 1. The constraint that SSFRs as quantum measurements are for observables, which commute with observables, whose eigenstate the state at the passive boundary is, poses very strong constraints on what happens SSFR. Furthermore, preferred extremal is analog of Bohr orbit and cannot cannot be arbitrary pair of 3-surfaces. Therefore, when the CD changes, the preferred extremal also changes as a whole meaning also that also energy changes. These conditions could force adiabatic picture and the analog of Uncertainty Principle for classical energies as function of CD size.
- 2. The sequence of SSFRs could be also analogous analogous to what happens for a particle in box as the size of the box increases adiabatically: adiabaticity would actually be a hypothesis about what happens in the steps consisting of unitary evolution and SSFR. In adiabatic approximation the coefficients in the superposition of the energy eigenstates do not change at all: only the energies would change.

- 3. In thermodynamics this kind of process would correspond to a cooling, which could serve as a natural quantum correlate for the cooling in cosmology. In accordance with the idea that quantum TGD in ZEO corresponds to a complex square root of thermodynamics, one could interpret zero energy state as complex square root of thermal partition function for cosmology assignable to CD. The hierarchy of CDs would define Russian doll cosmology.
- 4. A further manner to understand this is in terms of Uncertainty Principle. As the size scale of CD given by temporal distance between its dips increases, the classical energy decreases. Intuitively the reduction of the classical energy is easy to understand. Increasing CD and keeping the 3-surface as such at passive boundary reduces time gradients at the passive boundary and space-time surface becomes more flat. Energy density is proportional to time gradients of coordinates and its therefore reduced. This argument is also used in inflation theories.
- 5. Change is the prerequisite of conscious experience and there would be indeed change also at the passive boundary of CD contributing to conscious experience. But in some sense this contribution the "soul" should *not* be changing! "Adiabaticity" would translate this idea to the language of physics.

What happens to CD in long run? There are two options.

- 1. The original assumption was that the location of formerly passive boundary is not changed. This would mean that the size of CD would increase steadily and the outcome would be eventually cosmology: this sounds counter-intuitive. Classically energy and other Poincare charges are conserved for single preferred extremal could fail in BSFRs due to the fact that zero energy states cannot be energy eigenstates.
- 2. The alternative view suggested strongly $M^8 H$ duality [L66] is that the size of CD is reduced in BSFR so that the new active boundary can be rather near to the new passive boundary. One could say that the reincarnated self experiences childhood. In this case the size of CD can remain finite and its location in M^8 more or less fixed. One can say that the self associated with the CD is in a kind of Karma's cycle living its life again and again. Since the extension of rationals can change in BSFR and since the number of extensions larger than given extension is infinitely larger than those smaller than it, the dimension of extension identifiable in terms of effective Planck constant increases. Since $n = h_{eff}/h_0$ serves as a kind of IQ, one can say that the system becomes more intelligent.

Also the temperature assignable to CD remains finite. In cosmological scales it could correspond to the analog of the temperature assignable to CMB. TGD based view about stars as blackhole like entities [L99] leads to the identification of the Hagedorn temperature assignable to the volume filling flux tube giving rise to star with the Hawking temperature of dark radiation at gravitational flux tubes. Even CMB temperature could be assigned with dark photons at gravitational flux tubes. The asymptotic temperature for CD before BSFR could correspond to this temperature.

One expects that the center of mass coordinates of cm do not appreciably change during the quantum evolution. The hierarchy of CDs would imply that the Universe decomposes effectively to sub-Universes behaving to some degree independently. The view about Karma's cycles provides a more precise formulation of the pre-ZEO idea that systems are artists building themselves as 4-D sculptures. In particular, this applies to mental images in TGD based view about brain. The assumption that stars correspond to repeatedly re-incarnating conscious entities allows to solve several time anomalies in cosmology [L99] so that there would be a direct connection between cosmology and theory of consciousness.

There could be a relationship between quantal flow of geometric time by SSFRs and p-adic variant of time coordinates giving a reason why for p-adicity.

1. TGD predicts geometric time as a real variant and p-adic variants in extensions of various p-adics induced by given extension of rationals (adelic space-time and adelic geometric time). Real and p-adic times share discrete points in the extension of rationals considered: roots of

octonionic polynomials defining space-time surfaces as roots for their "real" and "imaginary" parts in quaternionic sense [L103]. The roots of the real polynomial with rational coefficients giving octonionic polynomial as its continuation define space moments of M^4 linear time assignable to special SSFRs. p-Adic time associated with the p-adic balls assignable the points are not well-ordered. One cannot tell about two moments of time which is earlier and which later.

2. This could relate to the corresponding lack of well ordering related to "clock time" associated with self at given level of evolutionary hierarchy defined by the extension of rationals. The increase of "clock time" as a distance between tips of CD for a sequence of small state function reductions (weak measurements) occurs only in statistical sense and "clock time" can also decrease. The moments of time correspond to roots of the real polynomial define "special moments in the life of self", one might say.

At the limit of infinite-D extension the roots of the polynomial define algebraic numbers forming a dense set in the set of reals. Cognitive representation becomes dense set. These "special moments" need not however become dense.

3. One can raise an interesting question inspired by self inspection. As one types text, it often happen that the letters of the word become in wrong order, change places, and even jump from a word to another one. The experienced order of letters assignable to a sequence of SSFRs is not the same as the order of letters representing the order for the moments of geometric time. When one is tired, the phenomenon is enhanced.

Neuroscientists can certainly propose an explanation for this. But could this be at deeper level quantum effect based on the above mechanism and have a description in terms of padicity assignable to prime p defining a ramified prime for the extension of rationals involved? When one is tired the metabolic resources have petered out and the IQs $n = h_{eff}/h_0$ defined by dimensions of extensions of rationals for the distribution of extensions tend to reduce, cognitive resolution for time becomes lower and mistakes of this kind become worse.

There is a further technical detail involved. For SSFRs the temporal distance between active boundary and passive boundary increases at least in statistical sense. It seems that one must define the inner product in S-matrix elements for the unitary step preceding SSFR using the previous state basis as sub-basis of the new state basis in the case that CD increases. In adiabatic approximation the S-matrix elements would be overlaps for the states with different size of CD and analogous to matrix elements between states of particle in boxes with the same fixed end but different moving end.

BSFRs in **ZEO**

Details of BSFR are not completely fixed. One can consider two options. Both options must satisfy the condition that the states at passive boundary of CD identified as superpositions of 3-surfaces remain invariant during the sequence of SSFRs. The tangent space-to the space-time surfaces need not however remain invariant. Therefore the classical energies of space-time surfaces can change since the energy densities are proportional to time derivatives of embedding space coordinates.

1. The size of CD increases steadily as was the original proposal and is thus not reduce in BSFRs. The problem with the steady increase seems to be that the size of CD becomes infinite eventually and the state evolves to what looks like cosmology. If the energy assignable with zero energy state is conserved, the energy density of matter inside CD increasing without limit becomes arbitrarily small. Is this a catastrophe?

For TGD inspired cosmology this is the case at the limit of big bang in the sense that the energy density goes like $1/a^2$ (cosmic string dominance) and energy in a co-moving volume vanishes like a, where a is light-cone proper time. One can think that CD defines only perceptive field and that space-time surfaces continue also outside CD up to the maximal size of CD in the hierarchy of selves involved. The zero energy state would have finite energy energy but density of energy would go to zero at the boundary of CD. The perceptive field of conscious entity would increase steadily in size.

As found, energy need not be conserved in the subsequence SSFRs because Gaussian wave packets of CDs around given size are required so that eigenstates of energy are not in question and the reduction of the width of Gaussian in the sequence of SSFRs implies reduction of average energy. Only the superpositions of 3-surfaces at the passive boundary of CD would be conserved.

Even the conservation of energy combined with the increase of CD need not be a catastrophe. In matter dominated cosmology the conservation of mass takes place with respect to cosmological time which corresponds to the proper time measured as temporal distance from the passive tip of CD. This cosmological mass is not energy but closely relates to it. What looks of course counter-intuitive is that every self would evolve to a cosmology.

2. The size of CD could be also reduced in BFSR [L103]. $M^8 - H$ duality and existence of "braney" solutions encourages to take this option serious. The 6-D brane like entities correspond to t = constant sections for linear M^4 time t. They would represent special moments in the life of self. The exceptional 6-D roots of octonionic polynomials as branes would emerge to the perceptive field conscious entity at these moment. Discontinuity of classical space-time evolution as SSFR. Every time-reversed re-incarnation of self would have have "childhood" and experience increase of CD from some minimal size to maximal size.

Since the size of CD can be reduced, it could happen that the CD remains stuck below certain maximal size for ever. The associated mental images would continue living in the geometric past of bigger CD associated with self. The sub-CDs in past would represent memories of self. Cosmos in 4-D sense would be full of life. The interpretation of CD as perceptive field allows this. CD could also increase and become even a cosmology! This picture looks attractive from the view point of consciousness.

- 3. One can however invent an objection against ZEO, one might even speak about paradox.
 - (a) Suppose that in biological death I indeed re-incarnate with opposite arrow of time and continue to live towards geometric past. Suppose also that I re-incarnate as more advanced human being - at least in statistical sense. Human beings have parents. But how can I have parents in the former geometric future, if my parents how have already died live in the former geometric past?
 - (b) The only solution of the paradox seems to be that the magnetic body (MB) the boss - does not disappear in the death of biological body (BB). The MBs of my parents continue their existence and in my biological death means their separation in stanard time direction and meeting in the new time direction. They meet, fall in love, and give rise to my birth but all this in opposite time direction.

This would provide an answer to a long-standing question about whether MBs are preserved in biological death or not. My view has been that biological death is more or less that MB loses interest in my BB and directs attention to something more interesting. One could however argue that also MB is generated in birth and genes code also for it so that it would die. If directing attention corresponds to BSFR MB would continue to exist after biological death. This particular reincarnation - CD - would be like vortex in the flow of time.

(c) Can one find any support for this crazy looking proposal? TGD Universe is fractal and lower levels in the length scale hierarchies are slaves. In particular, bio-chemical level serves as the slave of MB expected to obey kind of shadow dynamics. If the proposed topological dynamics of MBs solving the above paradox has a miniature representation at the level of DNA, one could take the proposal with some seriousness.

In meiosis (http://tinyurl.com/n5eqkdn) germ cells, whose chromosomes are coctails of paternal and maternal chromoses (PCs and MCs), are formed. In fertilization (http://tinyurl.com/ngzwhcq) - in some sense a (time?) reversal of meiosis - pairs of PCs and MCs are formed. The fusion of paternal and maternal germ cells could be indeed seen in topological sense as a time reversal of replication. The replication of soma cells involves mitosis (http://tinyurl.com/p351kwr) forming pairs of chromosomes of PCs and MCs.

Could the chromosomal dynamics be a miniature version of the proposed dynamics at the level of MB even at the level of organisms? If so, mitosis at the level of MB would correspond to a loose pairing of paternal and maternal MBs - formation of a relationship. Our personal MBs as analogs of germ cells would be coctails of MBs of PCs and MCs formed by reconnection process.

What about replication? In the case of asexual reproduction (http://tinyurl.com/ y8odomtf) one could speak about replication at the level of MB of the entire organism. Also cell - and DNA replication would represent examples of asexual reproduction and in meiosis sexual reproduction of also DNA would take place.

When does BSFR occur? I have imagined several options, which need not exclude each other.

- 1. Could BSFR occur, when there are no observables at the active boundary commuting with those diagonalized at passive boundary. Measurement of observable at means generation of eigenstate in the extension of rationals and it typically occurs that the resulting state is outside the extension. Could BSFR occur when there are no observables in the extension of rationals in question.
- 2. $M^8 H$ duality predicts universal special solutions besides 4-D space-time surfaces. These 6-D analogs of branes correspond to n moments of linear M^4 time, where n is the polynomial whose octonionic continuation defines space-time surfaces in M^4 as roots of its real or imaginary part in quaternionic sense. At these branes 4-D space-time surfaces are glued together along their ends- space-time looks is analogous to piecewise continuous curve in time direction - and they would correspond to "special moments in the life of self" [L103]. When all these moments as special roots of the octonionic polynomial are experienced, BSFR would be the only possibility. The polynomial with rationals coefficients defining the octonionic polynomial defines the extension of rationals used so that this option could be consistent with the first option.
- 3. Is BSFR is forced to occur because there are no preferred extremals connecting the pairs of 3-surfaces exists anymore. Could it happen that the state becomes increasingly classical during the sequence of SSFRs and thus becoming more and more local in WCW (the "world of classical worlds", which is essentially the space of 3-surfaces at either boundary of CD). The unchanging part of the zero energy state associated with the time-reversed state as outcome of BSFR at the new passive boundary would be maximally classical. This might relate to the fact that the world looks so classical. Also the fact BSFRs themselves look classical smooth time evolution ending to the outcome of BSFR, creates the illusion of classicality [L98].

4.5.2 ZEO, life, and consciousness

The most important implications of ZEO relate to consciousness and quantum biology. One can understand act of free will and motor action in terms of BSFR. BSFR corresponds to motor action and its time-reversal. SSFRs correspond to sensory perception in either direction of time [L93]. Model for memory is one prediction and predicts precognition as time reversal of memory [K106] [L118]. Also the relationship between generation of insight and mechanical logic deductions can be understood. In biology ZEO leads to remote metabolism as a universal purely thermodynamical mechanism of metabolism. One can also understand zero energy states as superpositions of deterministic programs - quantum programs, functions in the sense of quantum biology, or quantum behaviors.

Act of free will, intentionality, and ZEO

Act of free will would correspond to BSFR that is quantum jump leading to final state with opposite arrow of time. Final state is a superposition of deterministic time evolution connecting the 3-surfaces in the superpositions defining initial and the final states. In this picture state function reduction leads to final state inducing time reversed time evolution so that classically the causal order is changed. What in standard picture - say neural activities - causes the outcome,

is caused by the outcome. Could it be that mere volitional act with sharp enough intention is needed? The correct deterministic time evolution is dictated by intention as consequence rather than cause!

Here I cannot avoid the temptation to tell about my own strange experiences. At this age one must remember to take the pills every morning. I have the habit of filling my pill dispenser every Monday morning. I do not bother to count the pills one by one. I just take randomly a bunch of them hoping that their number is correct. And it is! Quite too often! Similar thing happens in market when I pay with coins: I do not count the coins but just take a handful of them. The sum of the coins is correct quite too often! Could a mere sharp intention dictate the outcome. Could one learn gradually this kind of sharp intentions.

Could this be crucial for various skills like playing tennis or computer game, where one simply cannot react rapidly by computing the outcome since time does not allow it? Could this explain also mathematical/physical/.. intuition as skill to solve problems by making quantum jump directly to the solution of the problem.

Precognition and ZEO

It seems that neuroscientists are beginning to take remote mental interactions such as precognition, telepathy, and psychokinesis seriously. The popular article entitled "Scientists Discover That The Heart & Brain Respond To Future Events – Before They Happen" (see http://preview.tinyurl. com/y494hw5u) describes changing views of neuroscientists towards precognition.

In ZEO precognitions are naturally time-reversed memories. Classical signals giving rise to sensory experience arrive from geometry future in the standard frame. During sleep state precognition should be possible if sleep corresponds to time-reversed state for the self.

In the associative and computational models of brain our ability to predict the future is taken to be an extrapolation based on memories and experience of earlier life. This looks very reasonable but when one asks how these memories are represented, problems begin to appear. In TGD framework ZEO predicts that memories correspond to mental images in geometric past, in the simplest case, when the original event took place. This solves a huge problem of standard since memory storage becomes brain in 4-D sense rather than in 3-D sense [K106].

ZEO however implies that also time reversed memories are possible. If sleep state correspond to time reversed self about which we do not have direct memories, memories with reversed arrow of time would be possible in this state. Precognition becomes possible if these memories can be communicated to the wake-up state with the ordinary arrow of time. In dreams some parts of brain are awake and they could make possible this communication. The communicated information could be also conscious to some selves above or below us in the hierarchy. Dreams can indeed predict what happens during the next day. The classical book "An Experiment with Time" (see http: //tinyurl.com/jtqysty) of J. W. Dunne tells about precognitive dreams that he experienced.

Intuitive and formal logical reasoning in ZEO

The basic vision is that adelic space-time geometry provides correlates for sensory experience and cognition/imagination. Fermionic degrees of freedom would represent quantal Boolean mind. In ZEO given deterministic time evolution for 3-surface and induced spinor fields would give rise to sensory and cognitive time evolution and to Boolean evolution having interpretation as analog of logical deduction leading from premises to conclusions.

- 1. The basis of fermionic Fock states can be regarded as Boolean algebra. Superpositions and thus entanglement of fermionic qubits are however possible and one can speak about quantum Boolean logic. In standard view concepts are formally regarded as sets containing the instances of concept as elements. Quantum concepts could be superposition of quantum states representing the instances so that quantum abstraction would be much more complex notion than ordinary abstraction. Non-classical Boolean states would be superpositions of statements identifiable as abstractions. Schrödinger cat would be seen abstraction. "Dead" and "alive" would represent instances of this abstraction.
- 2. Zero energy states are superpositions of initial and final fermion states and there is also a superposition over 3-surfaces, and could be interpreted as representations for implications.

The sum $\sum_{n} S_{mn} |n\rangle$, where S denotes unitary S-matrix, represents a superposition over all transitions $|m\rangle \rightarrow |n\rangle$ allowed by laws of physics. These transitions could be interpreted as logical implications.

One could argue that by diagonalizing S-matrix one obtains only diagonal transitions and the situation is rather trivial: just logical identities. The point is however that in number theoretical physics the diagonalization of S would in general lead outside the extension of rationals determining the adele and is therefore not possible. Same number theoretical mechanism would also stabilize negentropic entanglement and could force BSFR. Only state big state function reduction extending the extension of rationals can reduce this kind of entanglement.

3. Probably every mathematician has pondered the mystery of mathematical insight. How for instance mathematical insight is generated? What eureka experience is basically? Insight would correspond naturally to a big state function reduction leading to a new state reversing the arrow of time.

Truth can be deduced in given system of axioms also mechanically - at least in principle. How does insight relate to a logical deduction leading to a theorem? The final state of quantum jump is superposition of classical time evolutions leading from the final state to geometric past. With respect to standard arrow of time it is superposition of logical deductions leading from various initial states- initial assumptions - to the final state - to the outcome of the deduction. Superposition of states at boundary of CD could be seen as an abstraction. Deterministic time evolutions would represent the mechanical deductions.

Note however that in the time reversed state arbitrary long time evolution in opposite time direction is in principle possible and would correspond to an arbitrary long ordinary deduction or computation [L55]. After that a return to the original arrow of time would take place and provide the solution. The formal deduction leading to the outcome would be indeed forced by the outcome rather than vice versa?

Metabolism in ZEO

ZEO has also deep implications for biology. As already explained, ZEO allows to understand what behaviors, biological functions are at fundamental level.

Why metabolism is needed can be understood in TGD view about dark matter as phases of ordinary matter labelled by the value of effective Planck constant $h_{eff} = n \times h_0$, where n has also interpretation as dimension of extension of rationals giving rise to the extension of adeles [L75, L74]. n serves as a kind of IQ labelling different evolutionary levels and is bound to increase in statistical sense. Not only biology but also self-organization involving also energy feed could be understand in terms of the hierarchy of Planck constant.

In ZEO remote metabolism suggests itself as a completely universal purely thermodynamical mechanism of metabolism. Usually system loses its energy by dissipation. If the arrow of time is non-standard, systems seems to receive energy from environment. Note that the duration of time spent in time reversed state does not matter! What matters is the increment of time between states with same arrow of time! Sleep state could be seen also as a way to collect metabolic energy. BSFR can be seen as an act of free will - motor action and sucking of metabolic energy from "environment" would be very natural.

The interpretation for the return to the original time direction by second BSFR would be as beginning of sensory perceptions in standard arrow of time as sequences of SSFRs. During this period subsystem would be dissipating energy to environment.

4.5.3 Under what conditions does BSFR take place and what happens in it?

In the following the question under what conditions "Big" state function reduction (BSFR) takes place and what happens in it.

Two kinds of state function reductions

The discussion however requires the basic ideas of ZEO as background.

Small state function reductions (SSFRs) are counterparts of so called "weak measurements", which are rather near to classical measurements in the sense that nothing drastic happens.

- 1. The passive boundary of CD does not shift but changes in size because active boundary shifts and this induces change of size. For state pairs defining zero energy states the members at passive boundary do not change and the coefficients of possibly time-entangled state defined as their superposition do not change. The members of state pairs at active boundary change and this change is induced by unitary time evolution between too SSFRs. This time evolution could be regarded as a generalization of adiabatic time evolution.
- 2. In statistical sense the active boundary shifts towards future and the size of CD increases. The temporal distance between the tips defines clock time in one-one correspondence with SSFRs. Note that the unitary evolution forms a superposition of CDs with different sizes and SSFR means localization to single CD size.
- 3. The moment "Now" of self would naturally correspond to the M^4 hyper-plane dividing CD into two pieces of identical size. The radius of this 3-ball would be r = T/2, where T is the temporal distance between the tips of CD. At this hyperplane expansion of 3-ball with light-velocity would transform to contraction.
- 4. The mental images of self would correspond sub-CDs and also they would shifts towards geometric future in the sequence SSFRs. They would form a kind of log file about the life history of self such that geometric time order would be opposite to subjective time order. Self could remember these experiences by sending signals to geometric future reflecting back in time direction - seeing in time direction would be in question.

What is in sharp conflict with natural expectation is that the memories would be stored in geometric future and part of them would become un-changing permanent part for the time reversed re-incarnation of self- kind of Karma.

Note however that self might have also mental images represented as sub-CDs in geometric past.

 $M^8 - H$ -duality suggests space-time picture about the "log files".

- 1. 4-D space-time surfaces in complexified M^8 having interpretation as complexified octonions are 4-D roots for octonion valued polynomial obtained as an algebraic continuation of a real polynomial with rational or even algebraic coefficients. $M^8 - H$ correspondence maps thee surfaces to minimal surfaces with 2-D singularities in H [L106, L103].
- 2. Besides this one obtains for any polynomial also special solutions as analogs of branes in M-theory. They have topology of 6-D ball and their projection to M^4 is $t = r_n$ hyperplane intersecting CD and with topology of 3-ball. r_n is a root of P and thus an algebraic number. I have called $t = r_n$ "very special moments in the life of self". Generalized vertices for particle reactions would correspond to partonic 2-surfaces localized at these 6-surfaces. At these surfaces incoming and outgoing partonic orbits would be glued together along their ends. The roots define positions of external particles at the boundaries of CD.
- 3. In SSFRs these balls at the active half of CD would shift towards future and new roots would emerge. These roots wold define a geometric representation of the memories of CD as "log file" increasing in size. If there are sub-CDs associate with them, one would have mental images shifting towards future.

2. "Big" state function reductions (BSFRs)

"Big" state function reductions (BSFRs) correspond to ordinary state function reductions (SFRs) in ZEO. In BSFR the roles of active and passive boundaries of CD are changed and the arrow of geometric time changes since the formerly passive boundary starts to shift to opposite time direction. State function reduction not commuting with the observables defining states at

passive boundary as their eigenstates would takes place and the state at passive boundary would be changed. It would be however fixed by quantum dynamics. The findings of Minev *et al* provide support for the change of the arrow of time in ordinary SFR [L98].

The passive boundary can be shifted towards future so that the size of CD would decrease. One can say that the re-incarnate would be experience childhood. Note that also part of the "log file" about often personal experiences of self towards end of its life defining the permanent part of self-hood of the re-incarnate would disappear. The interpretation in terms of Karma is suggestive.

Remark: During a discussion with Marko Manninen, Marko noticed that people who have had near death experience often report that they experienced their entire life like a film during these moments. Could the "log file" representing stored mental images give rise to this experience at the moment of death?

What happens in biological death from TGD perspective?

What happens in biological death can be taken as a guideline in attempts to understand what happens in BSFR.

1. Death certainly occurs if there is no metabolic energy feed to the system. Metabolic energy feed is guaranteed by nutrition using basic molecules as metabolites. Since the increase of h_{eff} quite generally requires energy if other parameters are kept constant and since the reduction of h_{eff} can take spontaneously, the metabolic energy is needed to keep the distribution of values of h_{eff} stationary or even increase it - at least during the growth of organism and perhaps also during the mature age when it would go to increase of h_{eff} at MB.

If the size of CD for at least MB correlates with the maximum value of h_{eff} or its average, the size of CD cannot grow and can be even reduced if the metabolic energy feed is too low. The starving organism withers and its mental abilities are reduced. This could correspond to the reduction of maximum/average value of h_{eff} and also size of CD.

One can argue that if the organism loses metabolic energy feed or is not able to utilize the metabolic energy death and therefore also BSFR must take place.

2. In ZEO self-organization reduces to the second law in reversed direction of geometric time at the level of MB inducing effective change of arrow of time at the level of biological body [L107]. The necessary energy feed correspond to dissipation of energy in opposite time direction. In biological matter energy feed means its extraction from the metabolites fed to the system. One could say that system sends negative energy to the systems able to receive it. A more precise statement is that time reversed subs-system dissipates and metabolites receive the energy but in reversed time direction.

In living matter sub-systems with non-standard arrow of time are necessary since their dissipation is needed to extract metabolic energy. The highest level dissipates in standard time direction and there must be a transfer of energy between different levels. This hierarchy of levels with opposite arrows of geometric time would be realized at the level of MB.

Death as a re-incarnation with opposite arrow of time

These observations suggest that one should consider the reincarnation with opposite arrow of time with wisdom coming from the death of biological systems.

- 1. We know what happens in death and birth in biological systems. What happens in biological death should have analogy at general level. In particular, in death the decay of the system to components should occur. Also the opposite of this process with reversed arrow of time should take place and lead at molecular level to the replication of DNA and RNA and build-up of basic biomolecules and at the cell level to cell replications and development of organs. How these processes could correspond to each other?
- 2. The perceived time corresponds to the hyperplane t = T/2 dividing CD to parts of same size. Here T is the distance between the tips of CD and therefore to maximal diameter of temporal slice of cd, which is 3-ball. The part of CD above it shifts towards future in SSFRs. In BSFR parts of the boundary of space-time surfaces at the active boundary of CD become

unchanging permanent parts of the re-incarnate - kind of log file about the previous life. One can say that the law of Karma is realized.

If CD decreases in size in BSFR the former active boundary keeps its position but its size as distance between its tips is scaled down: $T \to T_1 \leq T$. The re-incarnate would start from childhood at $T - T_1/2$ and would get partially rid of the permanent part of unchanging self-hood corresponding to interval $[T - T_1/2, T/2]$ so that the permanent part of reincarnate would correspond to $[T - T_1/2, T]$. Reincarnate would start almost from scratch, so to say. The part between $T - T_1/2$ and T would be preserved as analog of what was called BIOS in personal computers.

- 3. At the moment of birth CD possibly would thus decrease in size and the former passive boundary now in the range $[T T_1/2, T T_1]$ and lower tip of new CD at $T T_1$ would become active and the seat of sensory experience. Arrow of time would change. Where the analog of biological decay is located? The region of CD in the range $[T/2, T T_1/2]$ disappearing from "log file" is the natural candidate. This region is also the place, where the events related to birth in opposite time direction should take place.
- 4. The decay of the organism should therefore correspond to the development and birth of re-incarnated organism at the level of MB (it must be also remembered that genuine time reversal takes place at the level of MB and induces only effective time reversal at the level of ordinary bio-matter). The decay of organism dissipates energy in standard time direction: this energy could used by the re-incarnate as metabolic energy. How long lasting biochemical processes have effective time reversals depends on the quantum coherence scale determined by the size scale of corresponding CD.

Could the re-incarnations with opposite arrow of time be seen in bio-chemistry?

The possible occurrence of effective time reversals at the level of bio-chemistry could be perhaps tested experimentally.

- 1. Could the replication of DNA and RNA and build-up of various bio-molecules be effective time-reversals for their decays. Could the same apply to the replication of cells and generation of organs. Replication of DNA is self-organization process in which second DNA strand serves as a template for a new one. The decay of DNA should therefore involve two DNA strands such that the second DNA strand serves as a template for the effectively time reversed replication. The double strand structure indeed makes possible for the other strand to decay first. Cell replication should use another cell as replicate and same would happen in the cell decay.
- 2. An interesting mental exercise is to imagine the time reversals of various basic processes like transcription and translation. In the time reversal of translation of mRNA to aminoacid sequence the amino-acid sequence and mRNA would return to ribosome machinery, and amino-acid and tRNA codon associated with tRNA would return to form tRNA. mRNA strand would shift one step backwards and the process would repeat itself and finally mRNA strand would return to open DNA strand. In the time reversal of transcription of DNA to mRNA, mRNA strand would return to open part of DNA strand, decay to RNA codons and eventually DNA strand would close. It should be easy to check whether these processes really occur in the decay process.
- 3. The formation of stem cells involves de-differentiation. Could it mean time reversal of the entire process leading to a differentiated cell? Also this idea could be tested.

In biology pairs of various structures often occur. Could they correspond in some sense to effective time reversals of each other whereas at the level of magnetic body one would have genuine time reversals

1. Could the opposite inherent chiralities of MBs of DNA strands correspond to opposite arrows of time at the level of MB of DNA realizing dark genetic code [L44]? Could this be seen as a kind of explanation for the double strand structure of DNA. Could the passivity of DNA

strand with respect to transcription correspond to opposite arrow of time at the level of MB? Could the passive strand become active in time reversal?

2. Even brain has this kind of pairing. Right brain hemisphere is passive in the sense that it does not seem to contribute to wake-up intelligence (presumably identified as analytic intelligence). Could either hemisphere serve as a template in the development of brain or could this happen only at the level of MB of brain? Could different time arrows at the level of MB be used to understand the strange passive character of right brain and could one one understand the holism of right brain *viz.* analytic reductionism of left brain as reflection of the fact that dissipation as decay corresponds to time reversal for self-organization generating structures at the level of MB.

What about ordinary re-incarnation?

A couple of comments relating to the notion of re-incarnation in standard sense are in order.

- 1. Eastern philosophies talk about the possibility of liberation from Karma's cycle. Can one imagine something like this? The above picture would suggest that in this kind of process the reduction of the size of CD does not occur at all and therefore there would be no decay process equivalent to the growth of time reversed organism. This would serve as an empirical signature for the liberation if possible at all. CD would continue to increase in size or perhaps keep its size. It would seem that a new kind of non-biological source of metabolic energy would be needed.
- 2. Reincarnation is a basic notion in Eastern philosophies. In ordinary reincarnation person has memories about life of a person, who lived earlier. There is evidence for this. This cannot be understood in terms of time reversed re-incarnation.

Recall that there would be a hierarchy of selves and corresponding CDs within CDs. It has remained an open question whether CDs could also overlap? Could re-incarnation in ordinary sense be explained in terms of this kind of overlap?

Suppose that one has two overlapping CDs: CD_1 and CD_2 and that CD_2 extends farther to the future of CD_1 . The sub-CDs of CD_1 shift to future as the active part of CD_1 shifts to future and increases in size giving rise to a kind of log file defining the personal memories of CD_1 . In this kind of situation the mental images of CD_1 can enter to CD_2 and become mental images of CD_2 . This would be sharing of mental images but in different sense as compared to the fusion of mental images by entanglement, which could also require intersection of sub-CDs of mental images.

Could one imagine that the cosmos is full of selves serving as counterparts of memes wandering around and finding for selves hosting them by providing metabolic energy? Note that ZEO means that CD center of mass degrees of freedom do not carry any conserved quantum numbers so that the motion of these lonely CDs would not be restricted by conservation laws!

- 3. This picture suggests that CD:s form a conscious fractal atlas consisting of charts with various resolutions analogous to the atlas defining a covering of manifold by open sets. The earlier proposal was that in biological death MB redirects its attention to a new system. This picture would be modified: the MB of of CD_1 would still attend the time-reversed system and experience time-reversed life. Some sub-CDs of CD_1 would however belong to a new CD in its geometric future CD_2 . This conforms with the intuitive expectation that space-time surfaces continue outside CD and only the perceptive field of conscious entity is restricted to CD.
- 4. Mental images should correspond to sub-selves and therefore sub-CDs of CD. Contrary to what I have proposed earlier, it seems that after images cannot correspond to BSFR type re-incarnations of mental images nor re-incarnations in standard sense.

Mental images would shift towards the future together with active part of CD and form a kind of log file. Could after images be memories of previous mental images involving a signal time reflect from the the mental image in log file and creating the after image as a sensory memory of the earlier visual mental image? Or could one understand after images in terms of propagation of dark photon signals along closed magnetic loops giving rise to periodically occurring mental images.

In [L121] I discussed how the evolution of self by BSFRs could correspond to a transition to chaos as iteration of the polynomial defining the space-time surface. The proposed picture was that the evolution by SSFRs corresponds to iteration of a polynomial P assignable to the active boundary of CD. This would predict a continual increase of the degree of the polynomial involved. This is however only one possibility to interpret the evolution of self as iteration leading to chaos.

1. One could argue that the polynomial $P_{nk} = P_n \circ \dots \circ P_n$ associated with the active boundary remains the same during SSFRs as long as possible. This because the increase of degree from nk to n(k+1) in $P_{nk} \to P_{nk} \circ P_n$ increases h_{eff} by factor (k+1)/k so that the metabolic feed needed to preserve the value of h_{eff} increases.

Rather, when all roots of the polynomials P assignable to the active boundary of CD are revealed in the gradual increase of CD preserving P_{nk} , the transition $P_{nk} \rightarrow P_{nk} \circ P_n$ could occur provided the metabolic resources allow this. Otherwise BSFR occurs and self dies and re-incarnates. The idea that BSFR occurs when metabolic resources are not available is very natural for this option.

2. Could $P_{nk} \to P_{nk} \circ P_n$ occur only in BSFRs so that the degree *n* of *P* would be preserved during single life cycle of self - that *n* can increase only in BSFRs was indeed the original guess.

While preparing this contribution I learned about a highly interesting claim (https://tinyurl.com/yap8ss4p) made by the research group led by Harold Katcher. The claim is that the epigenetic age (there are several measures for it such as methylation level of DNA) of rats has been reduced up to 50 percent. The theory goes that epigenetic age of molecules would be controllable by hormonal signalling globally.

BSFR would mean death of conscious entity and its reincarnation with opposite arrow of time. The system would rejuvenate in the transition starting a new life in opposite time direction from childhood so to say - rejuvenation would be in question. Doing this twice would lead to life with original arrow of time but starting in rejuvenated state. The claim of the group suggests that living matter could do this systematically using hormonal control.

Tukdam and TGD

This piece of text was inspired by a document (https://rb.gy/abt8za) about a strange phenomenon known as Tukdam. What happens is that in Tukdam the person is physically dead but is believe to be in a continued meditation. There is no EEG, the heart does not beat, and there is no normal metabolism. However, the decomposition processes do not start. The condition can last up to a couple of weeks. Similar longer-lasting ones have been reported: a yogi can be buried underground for months in an oxygen-free state and then wake up.

This challenges neuroscience's view of the brain as the seat of consciousness. According to reports there could be awareness and a sensory experience consisting of different light sensations. The Tibetan Book of the Dead describes these experiences. Near-death experiences have many similar features [L126].

In the body in Tukdam, the area of the heart is reported to feel warmer to the touch than the rest of the body, but the thermometer does not detect this difference. This would indicate that the body receives metabolic energy at the cellular level from some other source than in the normal metabolism, and that living matter can detect what measuring devices based on the recent knowledge provided by modern physics cannot detect. Where could this energy come from? If one wants to answer this, one must also ask what happens in death and what is consciousness and what is life.

1. Dark energy and matter are the two basic puzzles of recent day physics. In the TGD approach, I have identified dark matter as a phase of ordinary matter, for which the effective Planck constant h_{eff} is much larger than normally.

In particular, the gravitational Planck constant $h_{eff} = h_{gr}$ assignable to gravitational flux tubes can be very large and makes quantum coherence possible even on astrophysical scales. Large Planck constants would be associated with the dark matter magnetic body, which would be the TGD counterpart to the magnetic field of Maxwell's theory, but would differ from it in many respects. As a quantum coherent unit, this magnetic body would control the ordinary biological body and induce its coherence. The classical energy of a magnetic body, consisting of volume energy and magnetic energy, would be dark energy.

- 2. In the TGD Universe dominated by zero energy ontology, consciousness is a universal phenomenon and present on all scales, from elementary particles to the level of the cosmos. Even galaxies, stars and planets would be conscious beings. Also life and death would be universal phenomena. Likewise, the biological decomposition process associated with death would correspond to the universal decomposition process, which would essentially correspond to the decomposition of magnetic monopole flux tubes (magnetic catabolism), which would induce the catabolism of the breakdown of biomolecules. Its time-reversed version would be magnetic anabolism and induce the building of bio-structures such as molecules.
- 3. The fundamental metabolic processes would be essentially magnetic anabolism and catabolism induced by "big" state function reductions (BSFRs) changing the arrow of time and inducing the biological anabolism and catabolism. Death would mean reincarnation with the opposite arrow of time.

In Tukdam, the biological body would be dead, but the magnetic body would still be alive and prevent the biological decay from starting. The disintegration of the magnetic body would start in Tukdam much later than normally, and initiate the disintegration of the biological body. The content of the conscious experience in Tukdam, light sensations and deep peace, would come from the magnetic body. The dead biological body would not provide contribution from sensory input, motor activity, and cognition.

By a strange accident, just before seeing the document about Tukdam, I wrote an article [L146, L152] about a seemingly completely unrelated topic, solar flares related to the reversal of the direction of the sun's magnetic field in the solar cycle, which has a period of 11+11 years.

The reversal of the Sun's magnetic field would correspond to magnetic catabolism as the breakdown of long monopole flux tubes into very short parts. It would be followed by magnetic anabolism as their re-fusion into long flux tubes. The solar cycle would correspond to the sleep-wake cycle, or more precisely: a series of lives in different directions of time. Death would only be a change of time's arrow, nothing final.

The model unexpectedly leads to a biological analogy and to understanding what might happen to the magnetic body in biological death.

4.5.4 Conditions on the periods with reversed arrow of time

In zero energy ontology (ZEO) falling asleep (death at"my" level of self the hierarchy) corresponds to ordinary - or "big" - state function reduction (BSFR) and also means a reincarnation with opposite arrow of time. We would be therefore conscious during sleep and wake-up would correspond to falling sleep of that other, time reversed self.

When I fall asleep, I wake-up later tomorrow morning for instance, not yesterday morning. It is interesting to see what kind of conditions this implies and whether it is possible to satisfy this easily and even more interesting is to see whether a time travel to the geometric past - maybe the Golden Youth - could be possible.

The following assumptions are made about what happens in BSFR.

- 1. Causal diamond (CD) is a correlate for self. CD is obtained by gluing together two identical half-cones along their bottoms. Moment "Now" corresponds to the largest hyperplane $T_{now} = T$ (origin of time coordinate is at either (call it "lower") tip of CD).
- 2. During the sequence of SSFRs defining self, the 3-surfaces at the passive boundary of self are fixed although their 4-D tangent space changes and corresponds to the unchanging part of selfhood soul one might say. The opposite active boundary of CD and 3-surfaces at it

change and shift towards geometric future. This gives rise to wake-up consciousness involving sensory input and thoughts, emotions etc. induced by it. Each SSFR is preceded by the analog of unitary time evolution.

3. BSFR means a death of self (subself) and its reincarnation with an opposite arrow of time. One can equally well speak about the analog of falling in sleep and waking up after that for some level of hierarchy of selves. The self born in the death of the self with an opposite arrow of time self has no direct memories about the state. Self can however have memories about dreams in which part of say brain is awake. These memories store information about what self experienced during the sleep.

In BSFR the active boundary of the CD becomes passive and is frozen. The size of CD is scaled down so that CD becomes small: this implies that the reincarnated self has a childhood and much of the memories - often not pleasant - stored near the active boundary as subselves living forth and back as conscious entities disappear. The surviving memories of self become "silent wisdom" of the reincarnated self.

4. If CD belongs to a larger CD, call it CD_{super} representing a larger unit of consciousness, the sub-CDs must shift to the same direction as the active boundary of CD_{super} . Otherwise the sub-CDs would drop from the flow of consciousness. This is analogous to co-movement of matter in cosmology.

Note that the mental images of self correspond to sub-CDs around T_{now} and shift towards geometric future as CD increases and new mental images emerges at T_{now} plane: by $M^8 - H$ correspondence these special moments in the life of self correspond to roots of the polynomial defining space-time surface and reside are the upper half-cone of the CD. As CD increases, new roots pop up inside the upper half-cone near the T_{now} hyper-plane for some particular SSFRs. Completely counterintuitively, the mental images about past experiences are therefore in the geometric future of T_{now} hyperplane!

The proposed picture must be consistent with everyday experience. Call the two periods of self sleep wake-up and sleep label the two different BSFRs by "sleep" and "wake-up".

1. In each SSFR CD size increases - at least in statistical sense this implies that T grows. Each SSFR corresponds to a scaling for the CD shifting its active boundary towards the geometric future. During its life cycle CD experiences scaling Λ :

$$T_{now} \rightarrow T_{now,sleep_1} = \Lambda(SSFR)T_{now} \ , \ \Lambda(SSFR) > 1$$

2. When the system falls in sleep the size of CD is scaled down so that also the value of T_{now} is scaled down by $\Lambda_{BSFR} < 1$:

$$T_{now,sleep_2} = (1 - \Lambda(BSFR)) 2T_{now,sleep_1} = (1 - \Lambda(BSFR)) \Lambda(SSFR) 2T_{now}$$
, $\Lambda(BSFR) < 1$

After that the CD begins to increase in size by small scalings in SSFRs to opposite time direction and T_{now} begins to decrease from its value $T_{now,sleep}$ begins to decrease.

3. If CD belongs to a bigger CD - call it super-CD - representing a larger unit of consciousness with a longer life cycle, one can argue that the CD must shift to the same direction as the larger CD increases. Otherwise the CD would drop from the flow of consciousness defined by super-CD. This is analogous to co-movement of matter in cosmology. Therefore a given life cycle corresponds also a shift ΔT of sub-CDs towards the growth direction of super-CD takes place and one has for the time coordinate $T_{super,now}$ of the super-CD. Therefore one must perform shift $T \rightarrow T + \Delta T$ for $T_{now,sleep_1}$ and $T_{now,sleep_2}$ to take into account the drifting. This gives for the moments "Now" before ad after the shrinking of CD in BSFR (falling asleep):

$$T_{super,now,sleep_1} = T_0 + T_{now,sleep_1} + \Delta T$$
,

$$T_{super,now,sleep_2} = T_0 + (1 - \Lambda(BSFR))2T_{now,sleep_1} + \Delta T$$

4. Similar formula holds true for the moment of wake-up. In the previous formula T_{now} is replaced with $T_{now,sleep_2}$ and one has

$$\begin{split} T_{super,now,wakeup_1} &= T_0 + \Lambda^{1)}(SSFR)T_{now,sleep_2} + \Delta T^{1)} \ , \\ T_{super,now,wakeup_2} &= T_0 + (1 - \Lambda^{1)}(BSFR))\Lambda^{1)}(SSFR)2T_{now,sleep_2} + \Delta T^{1)} \end{split}$$

The parameter T_0 depends on the choice of the origin of time for super-CD but is irrelevant.

One can deduce a consistency condition for the parameters of the model.

1. During the sleep period the time coordinate $T_{super,now}$ for moment "Now" in the coordinates of larger CD changes in the following manner:

$$\begin{split} T_{super,now,sleep} &= T_0 + T_{now,sleep_1} \to T_{super,now,wakeup} \\ &= T_0 + \Lambda^{1)}(BSFR)T_{super,now,sleep_2} + \Delta T^{1)} \quad . \end{split}$$

 T_0 is an irrelevant parameter associated with super-CD. Note that there is breaking of time reversal symmetry since self associated with CD_{super} has fixed arrow of time unlike CD. Hence ΔT has at least in a statistical sense the same sign irrespective of the arrow of time of self.

2. This picture should be consistent with what we observe. When the tired average self fall a sleep at the evening, it wakes wake-up at the morning and is full of energy. Quite generally, wake-up occurs after time $\Delta T(sleep)$ meaning that the value of time T_{super} has increased by

$$T_{super,now,wakeup} = T_{super,now}(sleep_1) + \Delta T(sleep)$$

These two expressions for the value of $T_{super,now}(wakeup)$ must be consistent and this gives a conditions on the parameters involved:

$$\begin{split} &(1 - \Lambda^{1)}(BSFR))\Lambda^{1)}(SSFR)2T_{now,sleep_1} + \Delta T^{1)} \\ &= T_{now,sleep_1} + \Delta T + \Delta T(sleep) \quad . \end{split}$$

 $\Delta T(sleep)$ is given by

$$\Delta T(sleep) = [(1 - \Lambda^{1})(BSFR))\Lambda^{1}(SSFR)2 - 1]T_{now,sleep_1} + \Delta T^{1} - \Delta T$$

Intuitively it seems clear that for a given arrow of time it is not possible to wake-up before one falls asleep, and the condition $\Delta T(sleep) > 0$ for the standard arrow of time gives a constraint on the parameters. One cannot however exclude the possibility of time travel without dying or falling asleep first of the duration of time travel is much longer than that of wave-up period: $\Delta T^{(1)} - \Delta T$.

A special solution corresponds to $\Delta T(sleep) = \Delta T^{1)} - \Delta T$ and $(1 - \Lambda^{1}(BSFR)) 2\Lambda^{1}(SSFR) = 1$ giving $T_{now,sleep_2} = T_{now}$.

4.6 Some questions concerning zero energy ontology

Zero energy ontology (ZEO) [L112] gives rise to quantum measurement theory, which naturally extends to a theory of consciousness. In this article also consciousness aspect is central and my sincere hope is that it would not expel those physicist readers for whom consciousness still remains an unscientific notion.

Zero energy ontology (ZEO) briefly

ZEO provides a new ontology solving the key problem of the standard quantum measurement theory and quantum theory itself. It must be emphasized that ZEO is not a new interpretation created to put under the rug the logical paradox due to the conflict between non-determinism of state function reduction (SFR) and the determinism of unitary time evolution. Also the problem about the scale in which quantum world becomes classical disappers: the Universe is quantal im all scales and ZEO view about quantum jump makes the Universe to look like classical.

1. At the level of space-time dynamics, the notion of preferred extremal (PE) as a space-time surface is central: PE is an extremal of an action principle, which by general coordinate invariance must be highly unique once its intersection with either boundary of causal CD $= cd \times CP_2$ (cd is the intersection of future and past directed light-cones of M^4) is given. In the ideal situation this implies holography. Space-time surface is an analog of Bohr orbit and classical theory is an exact part of quantum theory.

There is probably a finite and discrete non-determinism analogous to that associated with soap films spanned by a frame: space-time is indeed a minimal surface as also soap films, and the 3-surfaces at its ends at boundaries of CD are part of the frame. Besides space-time surface is an external for Kähler action analogous to Maxwell action. The challenge is to interpret this finite non-determinism.

2. Quantum states, which I call zero energy states, can be interpreted as pairs of analogs of ordinary 3-D quantum states with positive energy. The members of the pair are at the opposite boundaries of CD. The convenient convention used also in quantum field theories (QFTs) is that the conserved quantum numbers at opposite boundaries sum up to zero classically: this brings in nothing new. At quantum level, 4-momenta are conserved only at the limit when CD has infinite size whereas classically the conservation holds true for all CD sizes: this reflects the Uncertainty Principle [L132]. Also in QFTs exact momentum conservation is obtained only at the limit of infinite quantization volume.

At the space-time level, zero energy states can be regarded also as superpositions of deterministic time evolutions: this is central for the interpretation.

- 3. SFRs are quantum jumps between zero energy states. SFR does not affect any deterministic time evolution but only replaces their superposition with a new one. This solves the paradox that was one of the key motivations for ZEO.
- 4. Zeno effect strongly suggests that there are 2 kinds of quantum measurements assignable to SFRs. For "weak measurements", "small" SFRs (SSFRs), the component of zero energy state at the either boundary of CD, to be called passive boundary (PB), is unaffected. Also the PB is unaffected apart from scaling. At the active boundary (AP) state changes and AP is scaled up (at least in statistical sense) and due to the scaling shifts to the geometric future.

The unitary time evolution preceding each SSFR corresponds to a scaling of CD (or rather, its M^4 projection cd) rather than time translation as its counterpart in string models. In A unitary evolution B between two SSFRs a superposition of CDs with varying sizes is formed and SFR localizes CD to a fixed size, which means the measurement of geometric time identifiable as the distance between the tips of CD. This geometric time correlates with the subjective time defined by the sequences of SSFRs. Subjective and geometric times are not identical as in standard ontology but only correlated.

5. "Big" SFRs (BSFRs) are the counterparts of ordinary quantum measurements. In the BSFR the roles of AB and PB of CD change so that the arrow of time changes since CD increases in the opposite direction of time (at least in statistical sense). For an observer with an opposite arrow of time, BSFR looks like an average deterministic time evolution leading to the final state of BSFR as observed experimentally by Minev *et al* [L98] [L98]. This illusion makes BSFR look classical in all scales although the TGD based dynamics is quantal in all scales due to the hierarchy of Planck constants predicted by TGD.

The possibility of time reversal forces a generalization of thermodynamics to allow both arrows of time: this kind of generalization was proposed long ago by Fantappie [J82] with

motivation coming from biology. Quite generally, self-organization processes seem to violate the arrow of time. External energy feed explains this partially but BSFR would be an important additional element of self-organization [L107, L130], especially so in living matter.

The assignment of "free will" to BSFR allows us to understand how free will can be consistent with the classical non-determinism of physics which would be exact.

ZEO based quantum measurement theory and therefore also physics naturally extends to a theory of consciousness, and one cannot avoid using this word, which is still a cursed word in the physicalistic camp.

Problems related to the mathematical realization of ZEO

There are several open questions related to ZEO and TGD inspired theory of consciousness and the existing view involves several working hypothesis which should be reduced to deeper principles or shown to be wrong.

At least the following questions related to physical interpretation of ZEO are still waiting for a detailed answer.

1. Preferred extremal (PE) property of space-time surfaces is central for quantum TGD [L122]. It follows from holography forced by general coordinate invariance (GCI), which however need not be ideal. How uniquely does the PE property of the space-time surface fix the space-time surface inside a given CD? The simplest situation is that the data at the end of the space-time surface at either boundary of the CD, fixes it completely. Space-time surface would be an analog of Bohr orbit.

Full determinism would imply that WCW for CD effectively reduces to the space of 3-surfaces assignable to either end of CD. The dynamics of SSFRs would reduces to that in fermionic degrees of freedom assignable to Boolean cognition since WCW degrees of freedom assignable to sensory perception would be fixed.

However, the dynamics of soap films spanned by frames suggests that this is not the case. The 3-D ends of the space-time surface define a frame and also dynamically generated portions of frame are allowed by the variational principle defined by the sum of a volume term and Kähler action as an analog of Maxwell action. The coefficient of the volume term has an interpretation in terms of a length scale dependent cosmological constant Λ .

Outside the frame space-time surface would be at least for a very large portion of extremals an analog of complex surface and therefore a minimal surface [L133] and also an extremal of Kähler action. At the frames only the equations for the entire action (sum of volume term and Kähler action) would be satisfied. The divergences of the conserved isometry currents for the volume term and Kähler action would have delta function type singularities but they would cancel each other. The portions of the frame could be analogous to singularities of analytic functions such as cuts and poles.

2. Number theoretic universality [L75, L74] in turn suggests that the inherent non-determinism of p-adic differential equations [K88] [L112] proposed to be a correlate of imagination could also relate to this non-determinism. How do the non-determinism of space-time surface, p-adic non-determinism, and non-determinism of the state function reduction relate to each other: could they be even one and the same thing?

ZEO based quantum measurement theory defines a theory of consciousness. How unique is the interpretation of zero energy ontology (ZEO) [L112]? Here 3 options suggest themselves corresponding to "western" and "eastern" world views and their hybrid.

- 1. For the western option, the space-time surface continues outside any CD as external world, in particular sub-CD and sub-CD is a correlate for the perceptive field of self.
- 2. For the eastern option, space-time ends at the boundary of any CD and sub-CD is not a correlate for the perceptive field of self and there is no constraint from the external world at boundaries of CD.

3. For the hybrid of these two options, conscious entity corresponds to a hierarchy of CD for which the highest level corresponds to CD for which space-time does not continue outside the CD. The highest level represents a God-like entity.

Problems related to ZEO based theory of consciousness

The new picture about sub-CDs at WCW level raises questions related to the TGD inspired theory of consciousness. This view involves several ad hoc assumptions related to the notions such as attention, mental image, memory, volition and intentions. Do these assumptions follow from more general assumptions or can some of them be simply wrong?

1. CD is a correlate for the perceptive field of self. Sub-CDs of CD define perceptive fields of subselves identified as mental images. What is the precise definition of sub-CD? Can one say that a sub-CD is created when a mental image is created. How does this happen? What determines the position and size of the sub-CD?

The sub-CD is defined by the restriction of zero energy state to sub-CDs so that sub-CDs are induced by CD. This condition is analogous to boundary condition in classical physics and freezes WCW degrees of freedom of sub-CD at the passive boundary (PB) but the failure of determinism leaves discrete degrees of freedom at the active boundary (AB) so that the dynamics of SSFRs is restricted to these sub-WCW degrees of freedom and fermionic degrees of freedom.

- 2. Where sub-CDs and subselves are located? The natural location for a minimal sub-CD and mental images is around 3-surface at which the classical non-determinism fails: the frames of the soap film in soap film analogy. One can develop a rather detailed picture about frames [L133] based on number theoretic vision realized in terms of $M^8 H$ duality [L119, L120, L124].
- 3. How sub-selves (sub-CDs) are created? Can they disappear? The notion of attention as generation of sub-CD achieved by a location of WCW ("world of classical worlds") spinor field at spacetime surfaces having their intersection with the PB of CD in a fixed set of 3-surfaces defining the sub-WCW is highly suggestive. This also affects the WCW spinor field of CD.

The attention can be directed in several ways. Redirection of attention means a movement of the region defining the content of mental images in the interior of a CD. Entanglement and classical communications would be naturally associated with attention defined in this manner. If minimal subselves are associated with the frames as loci of classical non-determinism, the set of targets of attention is discrete and finite.

This view about attention makes it possible to see also memory, anticipation, and intentions as special cases of attention.

4. The time evolution of CD itself would correspond to a scaling of CD (rather than translation), which by the failure of strict determinism brings in new discrete degrees of freedom related to the new frames becoming into the daylight as space-time surfaces increase. In the new picture, the sub-WCW property poses strong restrictions to the earlier picture about the development of sub-CD. The idea about silent wisdom as mental images preserved from the previous life after BSFR is not lost but is considerably modified.

In this picture, the small failure of classical determinism would be an absolutely essential element in that it makes possible a non-trivial theory of consciousness at the level of CD and at space-time level. Otherwise would have only fermionic degrees of freedom forgiven sub-CD. What is intriguing is that everything would be finite. SFRs would involve choices between finitely many alternatives and in this respect the theory would be analogous to the computationalistic approach: in fact, preferred extremals are analogous to computer programs.

4.6.1 Some background

In the sequel, some understanding of the basic ideas and notions of TGD proper [L122] is needed. Also ZEO as the target of critical discussion is briefly summarized.

TGD view briefly

Very concisely, TGD emerges as fusion of special and general relativities and has Poincare invariance of special relativity and General Coordinate Invariance (GCI) and Equivalence Principle (EP) as basic principles. Also the interpretation as a generalization of string models is possible: point-like particles are replaced by 3-surfaces instead of strings and world lines become space-time surfaces.

The notion of induction makes it possible to eliminate classical boson fields as primary dynamical variables and reduce them to the sub-manifold geometry of the space-time surface. For the simplest option, free second quantized quark fields of the embedding space $H = M^4 \times CP_2$ induced to the space-time surface remain as fundamental fermion fields and quarks serve as basic building bricks of both bosons and fermions as elementary particles [L113, L125].

Some understanding of notions such as the "world of classical worlds" (WCW) [K109], preferred extremal (PE) [K14], and various variants of holography [L119, L120] implied by general coordinate invariance (GCI) in TGD framework is assumed. Inclusions of hyperfinite factors of type II₁ (HFFs) [K143, K56] are central elements of quantum TGD proper.

Adelic physics [L74, L75] replacing real number based with number theoretical universal physics based on the hierarchy of adeles defined by extensions of rationals (EQs) and $M^8 - H$ duality (see Appendix 4.6.6) allowing number theoretic and geometric views about physics dual to each other is also assumed as the background.

Hierarchy of Planck constants $h_{eff} = n \times h_0$, with *n* identified as dimension of EQ, is the basic implication of adelic physics and central for quantum TGD. The phases labelled by h_{eff} behave like dark matter [K41, K42, K43, K44]. This hierarchy serves as a correlate for quantum criticality in arbitrarily long length scales.

Cognitive representations identified as points of space-time surface for which preferred coordinates of embedding space are in an extension of rationals are also central for the construction of the theory using $M^8 - H$ duality [L119, L120]. Galois group of EQ becomes number theoretical symmetry and is central in the description of quantum variants of cognitive representations [L23, L123].

Zero energy ontology (ZEO) [L112] is a key notion of quantum measurement theory. The basic prediction is that time reversal occurs in the ordinary state function reduction (SFR). This has profound implications for the interpretation of the quantum measurement theory [L98].

TGD inspired theory of consciousness can be seen as an extension of quantum measurement theory and relies on Negentropy Maximization Principle (NMP) as a basic dynamical principle [K80] [L130] implying second law for ordinary entanglement entropy.

$M^8 - H$ duality as it is towards the end of 2021

The view of $M^8 - H$ duality (see Appendix 4.6.6) has changed considerably towards the end 2021 [L132] 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 [L132] 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 [L132] 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 $X^4 \subset M_c^8$ (M^8 is complexified to M_c^8) as a "root" of its octonionic continuation [L119, L120]. 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 $X^4 \subset M^8$ [L103]. 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 [L132]. 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 [L124] 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 [L132]. 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.

ZEO

The TGD based view of consciousness relies on ZEO solving the basic paradox of quantum measurement theory. First, a brief summary of the recent view of ZEO [L112] is required. Some aspects of this view will be challenged in the sequel for sub-CDs.

- 1. The notion of a causal diamond (CD) (see Fig. ??) is a central concept. Its little cousin "cd" can be identified as a union of two half-cones of M^4 glued together along their bottoms (3-D balls). The half-cones are mirror images of each other. $CD=cd \times CP_2$ is the Cartesian product of cd with CP_2 and obtained by replacing the points of cd with CP_2 . The notion of CD emerges naturally in the number theoretic vision of TGD (adelic physics [L75])via the $M^8 H$ duality [L106, L119, L120].
- 2. In the ZEO, quantum states are not 3-dimensional if the classical determinism does not fail as it actually does, but superpositions of 4-dimensional deterministic time evolutions connecting ordinary 3-dimensional states. By holography forced by general coordinate invariance, time evolutions 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 by a new superposition. The classical determinism of individual time evolution is not violated. This solves the basic paradox of quantum measurement theory. There are two kinds of SFRs: BSFRs (counterparts of ordinary SFRs) changing the arrow of time (AT) and SSFRs (analogs of "weak" measurements) preserving the arrow of time that give rise to an analog of the Zeno effect (https://cutt.ly/yl7oIUy) [L112]. The findings of Minev *et al* [L98] provide strong support for ZEO [L98].

To avoid confusion, one may emphasize some aspects of ZEO.

1. ZEO does not mean that the physical states identified in standard quantum theory as 3-D time= constant snapshots - and assigned in ZEO to the opposite boundaries of a causal diamond (CD) - would have zero energy. Rather, these 3-D states have the same conserved quantities, such as energy. Conservation laws allow us to adopt the convention that the values of conserved quantities are opposite for these states so that their sum vanishes.

This is not new: in quantum field theories (QFTs), one speaks, instead of incoming and outgoing particles, external particles arriving from the geometric past and future and having

opposite signs of energy. That conserved quantities vanish in the 4-D sense, expresses only the content of conservation laws. A weaker form of this condition [L129] states that the total conserved Poincare charges are opposite only at the limit of infinitely large CD. CD would be an analog of quantization volume in QFTs, whose finiteness implies a small conservation of momentum.

2. ZEO implies *two* times: subjective time as a sequence of quantum jumps and geometric time as a space-time coordinate: for instance, the proper time of the observer. Since subjective time does not correspond to a real continuum, these times are not identifiable but are strongly correlated. This correlation has led to their identification although they are different.

4.6.2 How uniquely PE property fixes the space-time surface?

How uniquely the PE property fixes the space-time surface if its 3-D intersections with the boundaries of CD are given? This is the key question in this section.

Various variants of holography

General coordinate invariance (GCI) forces holography in the TGD framework. One can however consider several variants of holography [L119, L120, L130].

- 1. Holography in the standard sense would fix the space-time surface from the data of its intersection with either boundary of CD or the data associated with the light-like 3-surfaces at which the signature of the induced metric changes.
- 2. Strong form of holography (SH) states that 2-D data at the intersections of the light-like 3-surfaces and boundary of CD are enough to determine the space-time surface.
- 3. The strongest form of holography inspired by $M^8 H$ duality [L119, L120, L129] states that space-time region is determined by a rational value coefficients of a real polynomial extended to an octonionic polynomials, whose "root" is the space-time surface in M^8 . The *n* roots of a real polynomial would determine a 4-D region in M^8 and its image in $H = M^4 \times CP_2$ would be interpreted as space-time surface.
- 4. There is a variant of holography, which gives up the full determinism of classical field equations and gives rise to what look like classical topological analogs of Feynman diagrams.
 - (a) Consider first the particle level at the level of H. Particle lines generalized to 4-D orbits of 3-D surfaces representing particles. Particles as 4-D orbits of 3-surfaces contain lightline 3- D orbits of partonic 2-surfaces.
 - (b) Partons as building bricks of particles in the information theoretic sense, and correspond to partonic 2-surfaces at which the orbits of partonic 2-surfaces meet. Their orbits are 3-D light-like surfaces at which the signature of the induced metric of the space-time surface changes.

The partonic 2-D surfaces defining topological vertices belong to the 3-D sections of space-time surface with a constant value of M^4 time coordinate t to which one can map the 6-D brane-like entities of M^8 predicted by $M^8 - H$ duality [?]

This picture suggests that, besides the data at the boundaries of CD, also the data at the partonic 2-surfaces in the interior of CD are needed. This failure of classical determinism brings in the failure of the strongest form of holography. There would be a large number of PEs connecting the 3-surfaces at the ends of CD and they would correspond to the analogs of Feynman diagrams.

Zero energy state as a scattering amplitude would be a superposition over these diagrams. This superposition would not be however pre-determined as in the path integral but the zero energy state would define the superposition of paths in question.

Is the failure of classical determinism possible?

The possibility of classical non-determinism is suggested by the interpretation of space-time surfaces as generalized Feynman diagrams. These Feynman diagram entities would not however define an analog of path integral in TGD framework. Classical non-determinis would be a space-time correlate for the non-nondetermism at quantum level.

In this framework partonic 2-surfaces or equivalently the 3-D sections of the space-time surfaces with constant value of M^4 time would act as 3-surfaces at which the deterministic time evolution as a minimal surface would fail.

Another option is that light-like 3-surfaces containing the partonic 2-surfaces at very special moments of M^4 time define frames. These special values $t = t_n$ of M^4 time would be associated with 6-D branes predicted by M^8 picture as universal special solutions and their images in H would define "very special moments in the life of self" defined by the sequences of SSFRs defining the self.

- 1. The first hint comes from the dynamics of soap films. Soap films are minimal surfaces. The soap films spanned by 1-D frames consist of minimal surfaces glued together at the frames and this dynamics is non-deterministic in the sense that it allows several soap film configurations due to the different branchings at frames. At frames the minimal surface equations fail.
- 2. In TGD framework space-time surfaces as PEs are both minimal surfaces and extremals of Kähler action. In this case the 3-surfaces associated with "very special moments of time" $t = t_n$ could define an analog of a dynamically generated frame defining a 4-D soap film. The 3-surfaces at the ends of the CD would be fixed frames like those for soap films.

This realizes quantum criticality in the sense that the field equations outside frame do not involve the parameters of the action which sum of volume term and Kähler action. The interpretation as a non-linear analog of massless free field theory outside the frame conforms with the basic spirit of quantum field theory. These solutions of field equations rely on a a generalization of holomorphy to 4-D situation so that field equations reduce to purely algebraic conditions involving only the first derivatives of embedding space coordinates. The analogy is defined by the solution of 2-D Laplacian equation in terms of real or imaginary part of an analytic function.

Field equations consist of two terms, which are divergences for the conserved currents (4momentum currents plus color currents) defined by the induced metric in the case of volume term. In the interior of the space-time surface these divergences vanish separately for the volume term and Kähler action but not at the frame.

3. The field equations must hold true also at the 3-D frame but this need not be true for both volume term and Kähler action separately. The coupling parameters of the theory make themselves visible only via the frame. For the volume action the divergences of the conserved currents are orthogonal to the space-time surface. For K "ahler action, the divergences of the conserved currents contain to terms. The first term is proportional to the energy momentum tensor of Kähler action and orthogonal to the space-time surface.

Second term is not orthogonal to the space-time surface. For twistor lift the Kähler also has an M^4 part with a similar decomposition.

The sums of the parts of divergences orthogonal to the space-time surface and parallel to it must sum up to zero separately. This gives 8 conditions altogether so that the number of field equations is doubled at the frame.

- 4. Could it happen that the divergences of these two isometry currents are singular and proportional to 3-D delta function but that their sum vanishes and conservation laws are respected? The part of the frame in the space-time interior would be dynamically generated whereas the part of the frame at the ends of CD would be fixed.
- 5. The restriction to 3-D frames is not the most general option. The delta function singularities could be located also at 2-D partonic 2-surfaces, at light-like 3-surfaces at which the induced metric changes its signature, and at string world sheets which connect these light-like 3-surfaces and have 1-D light-like boundaries at them. The light-like 3-D surfaces would be

analogs of the cuts for analytic functions. Partonic 2-surfaces at the ends of light-like 3surfaces could be analogs for the ends of the cuts. String world sheets could serve as analogs of poles.

6. The non-determinism associated with the soap films and with frames suggests that there is a large number of 4-D "soap films with a given frame", which is fixed at the boundaries of CD but not in the interior of CD.

4.6.3 Questions related to the theory of consciousness

At the level of TGD inspired theory of consciousness theory, causal diamond (CD) defines a correlate of self or of its perceptive field. CD has sub-CDs which correspond to subselves experienced by self as mental images [L112, L130].

Concerning the evolution of self, the basic notions of "small" state function reduction (SSFR) as an analog of "weak measurement" and "big" SFR (BSFR) as an analog of ordinary SFR.

- 1. The first deviation from the standard ontology is that BSFR changes the arrow of time defined by the selection of PB of CD at which 3-D part of zero energy states remains unchaged during SSFRs.
- 2. The second deviation is that either boundary of CD and states at it remain unaffected in SSFRs whose sequence defines self as a conscious entity. This is the TGD counterpart for the Zeno effect of ordinary quantum theory in which repeated measurements of the same observable leave the state unaffected.

The details of the evolution of self are not fully understood and the proposed general view can be criticized.

- 1. How the constraint that sub-CD serves as a correlate for a classical perceptive field can be taken into account?
- 2. What is the precise definition of mental images as subselves? Are they at some special positions inside space-time surface?
- 3. What are the precise definitions of memories and conscious memory recall? The same question applies to the notions of intention, anticipation and attention.
- 4. Can the mental images be destroyed or do they only experience BSFR and continue to live with an opposite arrow of time and become unconscious to self? If a mental image can completely disappear, what could be the physical mechanism leading to its disappearance?
- 5. One can challenge the detailed picture of the notion of time evolution by SSFRs. The assumption about the drift of mental images towards future in the second half-cone of CD is ad hoc. Should it be replaced with a deeper assumption. Could one simply assume that they are stationary.

Three ontological options

The basic problem of ZEO is whether the causal diamond (CD) represents a perceptive field in the sense that the space-time surface continues outside the CD or whether CD is an independent entity in the sense that space-time surfaces do not continue outside CD. Conservation laws do not exclude either option.

ZEO allows 3 ontological options which might be called easter, western, and intermediate views.

Option I: Space-time surfaces are restricted inside CDs. Quantum universe is a collection of CDs containing space-time surfaces, which have ends at the boundaries of CD.

In this framework, space-time in cosmological scales is an idealization and could be perhaps explained in terms of the correlations between CDs. CDs do not form a fractal atlas of something unless one says that the atlas *is* the territory. CD is an independent entity rather than a perceptive field of sub-self. One can argue that for sub-CDs this picture is problematic since it seems that one loses totally the notion of objective reality as something existing outside CD. There are no sensory perceptions. Could the overlaps with other CDs create the experience about the existence of the external world?

Cosmology would be a mental construct and correspond to a very large CD. One would have a multiverse but only at the level of conscious experience. Option I is consistent with the eastern view that only subjective experience exists but not with the western view.

Option II: Space-time surface continues always outside all CDs and CDs can be interpreted always as perceptive fields. Option II conforms with the westerm option and implies that cosmology is something real.

Option III: Self is a hierarchy of CDs such that for sub-CDs the space-time surfaces continue outside the CD but for the largest CD this would not be the case. Sub-CDs would represent perceptive fields but the largest CD would be a God-like entity experiencing itself as the entire cosmos.

Meditators report altered states of consciousness in which the separation to self and external world ceases and the mind is empty. Also the experience of timelessness is mentioned. Could these states correspond to experiences without mental images (sub-CDs) created by SFRs at this highest level?

Option III is roughly consistent with both western and eastern views about consciousness. If one requires the notion of the external world as objective reality and accepts the proposed explanation of altered states of consciousness, option III remains the only possible option.

A general picture about the dynamics of sub-CDs

The ZEO based view of quantum measurement theory and the theory of consciousness inspired by it have not been precisely formulated for sub-CDs. In particular, the question of how sub-CDs as mental images are created, has remained unanswered.

The following proposal provides such a formulation and is consistent with Options I and III.

- 1. CDs form a fractal atlas of conscious maps but the map would be the territory since in general the space-time surfaces need not continue outside the CD. There would be no external particles as 4-D lines for generalized Feynman diagrams outside CD.
- 2. Sub-CDs correspond to mental images of CD as a conscious entity. From the point of view of consciousness theory, there are only experiencers (CDs) which can have experiences as mental images (have sub-CDs), be mental images of experiencers (be sub-CDs) and share mental images (intersecting CDs with common sub-CDs).
- 3. Consistency conditions for the quantum dynamics of CDs and sub-CDs and for the overlapping CDs give rise to correlations between the regions of the map. The shared regions are geometrically analogs for the intersections of the intersections of a covering of a manifold by open sets.
- 4. For sub-CD the interpretation of sub-CD as a perceptive field would be natural.

The first question is what does one really mean with sub-CD at the level of space-time surfaces.

- 1. Do the space-time surfaces of sub-CD continue outside sub-CD as space-time surfaces of CD? Does this imply that the quantum dynamics of sub-CDs in ZEO is completely dictated by that of CD? This is certainly not the case. Fermionic zero energy states associated with the sub-CD are possible and are analogous to quantum fluctuations. Note that in the TGD framework all elementary particles can be constructed from fundamental fermions (quarks).
- 2. If the PE (PE) property fixes completely the space-time surface, its intersections with the boundary of CD, this seems to be the case. If the classical dynamics is not completely deterministic, as suggested by the analogy with minimal surfaces spanned by frames, the situation changes.

Sub-CD defines a subsystem of CD with boundary conditions at the boundary of CD which do not completely fix the quantum dynamics of sub-CD. Quantum states as WCW spinor fields inside sub-CD could change in SFRs of sub-CD.

The tensor product of sub-CD with CD would not be ordinary tensor product but much more restricted one and Connes tensor product, related to inclusions of HFFs, would be a possible identification. A sub-system would be like an included hyper-finite factor of type II₁ (HFF).

Suppose that the classical dynamics is indeed non-deterministic and sub-CDs are defined in the proposed manner. How the view about WCW spinor fields changes as one restricts the consideration to sub-WCW.

1. The failure of the classical determinism forces to replace each 3-surface at PB with a discrete tree-like structure consisting of all PEs connecting it to AB. Sub-WCW as the space of PEs is larger than the space of 3-surfaces X^3 at PB. Zero energy states are defined in this sub-WCW and assign to a given X^3 a wave function in this discrete set allowing interpretation as wave function in a set of paths of the tree.

One cannot avoid the association with cognitive representations of adelic physics involving the number theoretic degrees of freedom characterized by Galois group of the extension of rationals associated with the polynomial defining the space-time region [L62, L123].

- 2. The activation of sub-WCW would mean an SFR selecting in WCW of CD such sub-WCW for which the space-time surfaces are such that their ends at sub-CD are fixed. This would correspond to SFR creating a sub-CD and corresponding mental image. This would answer the long standing question whether and how mental images can appear as if from scratch. This SFR would also represent a third kind of SFR having interpretation as a partial localization in WCW associated with CD. This also suggest that mental images could disappear suddenly. This "activation" could be seen as a directed attention.
- 3. WCW degrees of freedom at the boundaries of sub-CD are fixed. Also sub-WCW spinor fields make sense. One can allow the tensor product of Fock spaces of many-fermion states associated with the boundaries of CD. One would have a QFT like picture with sub-WCW degrees of freedom fixed at boundaries of sub-CD.
- 4. The tensor product of fermionic state spaces at the boundaries of sub-WCW makes sense and one can define zero energy states in the same manner as proposed hitherto. The only difference is that WCW degrees of freedom are frozen at the boundaries of sub-CD. At the level of conscious experience this means that the subself experiences the external world as fixed. This would be by definition the meaning of being subself.

The fermionic Fock state basis has an interpretation as a Boolean algebra so that fermionic zero energy states have an interpretation as Boolean statements of form $A \rightarrow B$. This would mean that consciousness of the subself would be Boolean, cognitive consciousness, thinking. This conforms with the Eastern view that ordinary consciousness is essentially thinking and that the higher level of consciousness as that associated with the highest level of the CD hierarchy of self is pure consciousness. Thinking assignable to the fermionic degrees of freedom would be seen as an endless generation of illusions. "Reality" in this interpretation would correspond to WCW degrees of freedom.

What restrictions must one pose on the quantum dynamics of CDs in the case of sub-CDs? Does the subjective evolution of sub-CD states by SSFRs and BSFRs make sense for sub-CDs?

- 1. The increase of the size of sub-CD makes sense and the proposed subjective evolution by scalings and SSFRs makes sense. The time evolution is also now induced by the increase of the perceptive field of a subself defined by the WCW associated with increasing sub-CD bringing in new 4-surfaces due to the classical non-determinism.
- 2. What about the interaction between CD and sub-CDs. Does this time evolution respect the condition that the space-time surfaces meet the fixed 3-surfaces at boundaries of sub-CD or is it possible that the SSFRs of CD destroy the subself by delocalization so that sub-CD as a mental images must be regenerated by localization in WCW.

3. Also the interaction between overlapping CDs and the sharing of mental images can be understood in this framework.

4.6.4 Comparison of the revised view of self with the earlier one

The revised view about TGD inspired theory of consciousness relies on the definition of subself at the level of WCW unlike the older view. In the following the new view is compared with the old view.

The view about SSFRs

Earlier picture

The earlier view about SSFRs was inspired by the M^8 picture.

- 1. The dynamics was assumed to involve both scaling of CD with respect to either tip of CD. The lower half-cone was only scaled whereas the upper half-cone was also shifted as required by the stationarity of the passive boundary. Dynamics at PB was passive in the sense that only a portion of the space-time surface became visible making also new states visible at it (Zeno effect) in the sequence of SSFRs. The idea about scaling leads to a rather concrete proposal for the S-matrix characterizing the scalings of CD.
- 2. The surfaces inside CD (or sub-CD) were assumed to be mirror symmetric with respect to the middle plane of CD. This assumption does not conform with the assumption that these surfaces define a perceptive field in the sense that they are parts of large space-times and continue outside CD.

The old view had several ad hoc features.

- 1. The creation of mental images was implicitly assumed without specifying what this could mean mathematically. These mental images were assumed to be created in the upper half-cone just above the t = T mid-plane of CD and shift to the geometric future with the upper half-cone of CD. The asymmetry between upper and half-cone could be seen as reflecting geometrically the future-past asymmetry but was ad hoc.
- 2. One can criticize the assumption that the memories about the events of the subjective past are located in the geometric future with respect to the mid-plane of CD.
- 3. Whether mental images can disappear or only die and reincarnate by BSFR, was not specified.

New picture In the new picture the situation is the following.

- 1. Also in the new picture, the time evolution by SSFRs would be a sequence of scalings of CD. The assumption about reflection symmetry of space-time surfaces is given up since it is inconsistent with the identification of sub-CD as a perceptive field. Also now the time evolution is passive in the sense that only a new portion of the space-time surface extending outside sub-CD is revealed at each step.
- 2. As in the previous picture, new discrete WCW degrees of freedom appear during the sequence of SSFRs and complexity increases. For both options only fermionic degrees of freedom remain if full determinism is assumed and if QCC is required also at the level of SFRs.
- 3. In the new view both directed attention, memory, and intention correspond to a generation of sub-CD by a localization in WCW fixing a subset of 3-surfaces at the PB of CD. Redirecting of attention would allow apparent movement of the sub-CD in the interior of CD and as a special case shifting the mental images in the time direction assumed in the earlier picture.
- 4. In the new view the loci of mental images are naturally associated with the loci of classical non-determinism that is 3-surfaces at the 4-D minimal surface branches.

5. $M^8 - H$ duality suggests that the branchings occur at H image points of the M^8 cognitive representation defined by the quark momenta which are algebraic integers for the extension of rationals defined by the polynomial defining $X^4 \subset M^8$. The non-determinism at $X^4 \subset H$ point set would correspond to non-determinism assignable to a bound state of quarks at corresponding point of M^8 .

Note that physical states correspond to total quark momenta which are rational integers, one can speak of Galois confinement meaning that physical states are Galois singlets. This gives an infinite hierarchy of bound states formed by a universal, purely number theoretical mechanism. All bound states could be formed in this manner.

The non-determinism at $X^4 \subset H$ point which corresponds to a subset of points as images of quark momenta composing the bound state would correspond to non-determinism assignable to a bound state of quarks at corresponding point of M^8 . There would be a hierarchy of CDs within CDs and hierarchy of mental images corresponding to the hierarchy of bound states.

The bound state momenta are mapped to $X^4 \subset H$ by $M^8 - H$ duality already described. In particular, the positions of quarks contained in 6-branes X^6 with a constant energy $E = E_n$ are mapped to a sequence of points at the boundary of cd of the system by M^8 -duality and it can be said to represent the positions of these quarks. These point sets define sequences of "very special moments in the life of self".

The targets of attention would therefore form a discrete set assignable to bound states of quarks and antiquarks. Note however that each 3-surface X^3 in the superposition defining the WCW spinor field at the PB of CD has its own discrete set loci of non-determinism. BSFRs can change the superposition of these 3-surfaces. The selection between branches is possible in BSFR but not in SSFRs.

6. An attractive idea motivated by ZEP is that volitional action could be interpreted in the new view as an SFR selecting one path at the node of a tree characterizing the non-determinism. Single deterministic time evolution analogous to a computer program would be selected rather than modifying the deterministic time evolution as in standard ontology. In the M^8 picture, the very special moments $t = r_n$ in the life of self correspond to the roots of a real polynomial. What happens when all roots have been experienced? Does NMP force the BSFR to occur since nothing new can be learned?

Comparison of the views about BSFR

Those aspects of BSFR in which old and new views differ are of special interest.

Earlier view

The fact that the notion of sub-CD and mental image were not properly formulated led to several ad hoc assumptions.

- 1. The possible failure of a strict determinism was realized. The failure of strict determinism was assigned to "very special moments in the life of self" associated with the images $E = E_n$ planes of $M^4 \subset M^8$ at which the partonic vertices as loci of non-determinism were assigned.
- 2. The mental images of previous life near the AB of CD were assumed to be inherited as "silent wisdom". Their contents was from the early period of life with opposite arrow of time and one can of course ask whether they were really "wisdom".
- 3. There were also assumptions about the change of the size scale of CD in BSFR. The idea that the reduction of the size scale guarantees that re-incarnate has childhood was considered. This assumption also prevents unlimited increase of the size scale of sub-CD.

New view

The new view makes it possible to develop a more detailed picture of what happens in BSFR.

1. The WCW localization at the AB of CD selects one of the branches of the space-time surface beginning at the PB. This selection of the branch happens to each 3-surface in the superposition of 3-surfaces at the PB defined by the WCW spinor field before BSFR.

2. The future directed tree becomes a past directed tree beginning from one particular branch at the AB. The initial and final space-time surface share a common space-time surface connecting the roots of the old and new trees. This is essential for having a non-trivial transition amplitude for BSFR at WCW level.

In the earlier view, the mental images interpreted as memory mental images and located near the boundary of CD were assumed to be inherited as "silent wisdom" by the time-reversed reincarnate. What happens now?

The notion of "silent wisdom" as inherited information still makes sense.

- 1. The new space-time surfaces originate from 3-surface which was selected by WCW localization in BSFR. Therefore the new space-time surfaces carry classical information about previous life.
- 2. The space-time surfaces originating from the new root are near to the space-time surface connecting the old and new roots. The WCW spinor field before and after BSFR musthave a strong overlap in order to make the transition amplitude large. This implies that information about previous life is transferred to the new life.
- 3. The nearness property could imply that they are easily re-created as perceptions by directed attention so that they would indeed be "silent" wisdom. These mental images are from the later part of the life cycle rather than from the early life as in the earlier picture. If aging means getting wisdom, then silent wisdom would be in question.

Does the notion of "silent wisdom" as mental images make sense?

1. Mental images - this includes both sensory and memory mental images and intentions) are naturally assignable to the loci of classical non-determinism at the images of the planes $E = E_n$ of the branched space-time surfaces associated with the new root ("very special moments in the life of self").

For the special space-time surface connecting the roots of old and new space-time surface, the surfaces $E = E_n$ in M^8 would not change and the mental images would carry information about previous life. Could one talk about potentially conscious "silent wisdom".

- 2. What happens to the mental images of self in BSFR? Can they be preserved or do they disappear or do they reincarmate by BSFR? The idea about preservation makes sense only for space-time surfaces connecting the roots.
- 3. What can happen to the size scale of CD in BSFR? The extreme option that CD decreases in size by shift of the formerly PB such that the time evolutions are fully determinimistic in the superposition of 3-surfaces. There would be no inherited silent wisdom and the self would start from scratch, live a chilhood. Otherwise these loci would define candidate for inherited silent wistom.

In the earlier picture the mental images corresponding to sub-CD could not disappear although it could die by BSFR and reincarnate with a reversed arrow of time. Can the mental image disappear now? Creation of mental image require metabolic energy feed: this explains 7 ± 2 rule for the number of simultaneous mental images. Could this happen when attention is redirected? Therefore one could argue that mental image must totally disappear when the attention is redirected.

On the other hand, time reversed mental image apparently feeds energy to the environment in the original arrow of time, i.e. apparently dissipates. Could this dissipation be interpreted as an energy feed for its time reversal.

Note that the total disappearance of the mental image means delocalization at the level of WCW and seems possible. The new view clearly challenges the idea about the Karma's cycle of self. This cycle appears in many applications of BSFR.

4.6.5 Conclusions

Also the article *Some comments related to Zero Energy Ontology (ZEO)*" [L112] written for few years ago challenged the basic assumptions of ZEO. One tends to forget the unpleasant questions but now it was clear that it is better to face the fear that there might be something badly wrong. ZEO however survived and several ad hoc assumptions were eliminated.

Progress at the level of basic TGD

The basic goal is to improve the understanding about quantum-classical correspondence. The dynamics of soap films serves as an intuitive starting point.

- 1. In TGD frame 3-surfaces at the boundaries of CD define the analog of frame for a 4-D soap film as a minimal surface outside frame. This minimal surface would be an analog of a holomorphic minimal surface and simultaneous exremal of Kähler action except at the frame where one would have delta function singularities analogous to sources for massless d'Alembert equation.
- 2. There is also a dynamically generated part of the frame since the action contains also Kähler action. The dynamically generated parts of the frame would mean a failure of minimal surface property at frame and also the failure of complete determinism localized at these frames.
- 3. At the frame only the equations for the entire action containing both volume term and Kähler term would be satisfied. This guarantees conservation laws and gives very strong constraints to what can happen at frames.

The frame portions with various dimensions are analogous to the singularities of analytic functions at which the analyticity fails: cuts and poles are replaced with 3-, 2-, and 1-D singularities acting effectively as sources for volume term or equvavelently Kähler term. The sum of volume and Kähler singularities vanish by field equations. This gives rise to the interaction between volume and Kähler term at the loci of non-determinism.

4. *H*-picture suggests that the frames as singularities correspond to 1-D core for the deformations of CP_2 type extremals with light-like geodesic as M^4 projection, at partonic 2-surfaces and string world sheets, and at 3-D $t = t_n$ balls of CD as "very special moments in the life of self" which integrate to an analog of catastrophe. T

Deformations of Euclidean CP_2 type extremals, the light-like 3-surfaces as partonic orbits at which the signature of the induced metric changes, string world sheets, and partonic 2surfaces at $r = t_n$ balls taking the role of vertices give rise to an analog of Feynman (or twistor -) diagram. The external particles arriving the vertex correspond to different roots of the polynomial in M^8 picture co-inciding at the vertex.

The proposed picture at the level of $H = M^4 \times CP_2$ has dual at the level of (complexified) M^8 identifiable as complexified octonions. The parts of frame correspond to loci at which the spacetime as a covering space with sheet defined by the roots of a polynomial becomes degenerate, i.e. touch each other.

Concerning the physical interpretation, a crucial step of progress was the interpretation of M^8 as analog of momentum space allowing to interpret $M^8 - H$ duality as an analog of momentumposition duality and of complementarity principle of wave mechanics [L132]. This forced to modify $M^8 - H$ duality in M^4 degrees of freedom to satify the constraints posed by UP.

There is a nice analogy with the catastrophe theory of Thom [A38, A19]. The catastrophe graph for cusp catastrophe serves as an intuitive guide line. embedding space coordinates serve as behaviour variables and space-time coordinates as control variables. One obtains a decomposition of space-time surface to regions of various dimension characterized by the degeneracy of the root.

Progress in the understanding of TGD inspired theory of consciousness

The improved view about ZEO makes it possible to define the basic notions like self, sub-self, BSFR and SSFR at the level of WCW. Also the WCW correlates for various aspects of consciousness

like attention, volition, memory, memory recall, anticipation are proposed. Attention is the basic process: attention creates sub-CD and subself by a localization in WCW and projects WCW spinor field to a subset of WCW. This process is completely analogous to position measurement at the level of H. At the level of M^8 it is analogous to momentum measurement.

One can distinguish between the Boolean aspects of cognition assignable to WCW spinors as fermionic Fock states (WCW spinor field restricted to given 3-surface). Fermionic consciousness is present even in absence of non-determinism. The non-determinism makes possible sensory perceptions and spatial consciousness.

A precise definition of sub-CD as a correlate of perceptive field at WCW level implies that the space-time surfaces associated with sub-CDs continue outside it. This gives powerful boundary conditions on the dynamics. For the largest CD in the hierarchy of CDs of a given self, this constraint is absent, and it is a God-like entity in ZEO. This leads to a connection between the western and eastern views about consciousness.

A connection with the minimal surface dynamics emerges [L133]. The sub-CDs to which mental image as subselves are assigned would be naturally associated with portions of dynamically generated frames as loci of non-determinism. If one identifies partonic 2-surfaces as vertices, one can interpret the collection of possible space-time surfaces for a fixed 3-surface at PB as a tree. All paths along the tree are possible time-evolutions of subself. The dynamics of consciousness for fixed 3-surface at PB becomes discrete and provides discrete correlate for a volitional action as selection of a path or a subset of paths in the tree. The reduction of dynamics of mental imagines to discrete dynamics would mean a huge simplification and conforms with the discreteness of cognitive representations.

Challenges

There are many challenges to be faced. The discrete dynamics of sub-self consciousness certainly correlates with the notion of cognitive representation based on adelic physics [L74, L75] and implying a discretization at both space-time level and WCW level. The Galois group for the extension of rationals acting on the roots of the polynomial plays a key role in this dynamics [L123, L124].

One teaser question remains. Localization requires energy quite generally and this conforms with the fact that mental images demand metabolic energy feed. It is possible to redirect attention and it remains unclear whether the mental image disappears totally or suffers BSFR.

This relates directly to the question whether consciousness continues after the physical death. If mental images (and corresponding sub-CDs) can disappear, the same can happen to us since we are mental images of some higher level self. If this cannot happen, BSFR means death and reincarnation with an opposite arrow of time in a completely universal sense. For instance, sleep period could correspond to a kind of death at some level of the personal self hierarchy generalizing the Id-ego-superego hierarchy of Freud. This would explain why we have no memories of the sleep period.

4.6.6 Appendix: M^8 - and H views about classical non-determinism and particle reactions

M^8 picture and $M^8 - H$ duality

In M^8 picture, space-time surfaces correspond to real projections of 4-D complex "roots" of octonionic polynomials obtained from real polynomials with rational coefficients by algebraic continuation, i.e. by replacing real coordinate by complexified octonion coordinate [L67, L68, L69] [L119, L120]. The interested reader finds a rather detailed summary of $M^8 - H$ duality in Appendix 4.6.6.

 $M^8 - H$ duality maps the point of $M^4 \times E^4$ to a point of $M^4 \times CP_2$ such that the point of $M^4 \subset M^4 \times E^4$ is mapped to some point of $M^4 \subset M^4 \times CP_2$. $M^8 - H$ duality is not a local map. Rather, the normal space of a $x \in X^4 \subset M^8$ goes to a point of CP_2 characterizing its quaternionic normal space.

1. To be a 4-D "root" in the complex sense means that the real part of a complexified octonionic polynomial determining the space-time surfaces vanishes. The number theoretic content of this condition is that the normal space of the space-time surface is quaternionic and therefore

associative. The second option would be that the tangent space is associative but this gives only M^4 as a solution.

2. At a given point there are n roots and some of them can coincide in some regions of the space-time surface. These regions correspond to the branchings of the space-time surface at which particle-like entities identified as space-time surfaces meet and interact.

The quaternionic normal plane at this intersection is not unique so that several CP_2 points of $X^4 \subset H$ correspond to a single point of $X^4 \subset M^8$. The extreme situation is encountered in a point-like singularity when the normal plane at a given point of M^4 is a sub-manifold of CP_2 .

The interpretation is as particle vertices. The intuitive expectation is that they correspond to partonic 2-surfaces and perhaps also string world sheets. These surfaces are mapped to those in $M^4 \times CP_2$ by $M^8 - H$ correspondence.

3. Also 6-D brane like entities are predicted as universal "roots" they correspond to 6-spheres in M^8 with M^4 projection which is a 3-ball with constant value $E = E_n$ of energy as counterpart of the Minkowski time coordinate such that E_n is the root of the real polynomial defining the octonionic polynomial. The momenta $(E_n, p = 0)$ are mapped to points $t_n = (\hbar_{eff}/E_n, 0)$ and define "very special moments of time in the life of self".

The points with $p \neq 0$, in particular the points corresponding to quark momentum, however correspond to $t < t_n$ at the boundary of cd with size $L(p) = \hbar_{ef}/\sqrt{E_n^2 - p^2}$. To these moments the failure of classical determinism giving rise to one particular kind of quantum non-determinism is concentrated. Note that points of double hyperboloid of M^4 with opposite energies are mapped to opposite boundaries of cd.

- 4. The intersections of 4-D "roots" with 6-D brane-like entities are 2-D and it might be possible to interpret them as analogs of either partonic 2-surfaces or string world sheets at which several roots become degenerate of octonionic polynomial co-incide. Outside the singularity, the roots do not coincide and define separate space-time sheets and it is natural to interpret them as external particles of a particle reaction.
- 5. At the light-like orbits of partonic 2-surfaces the induced metric for the *H*-image of the space-time surface becomes degenerate since its signature changes. Could one say that the Minkowskian and Euclidean roots coincide at the partonic orbits?

One can also wonder what the M^8 interpretation of wormhole contacts having two throats could be. Do the two throats correspond to two coincing roots at the level of M^8 having different normal spaces and mapped to separate 2-surfaces in H?

Catastrophe theoretic analogy

Consider the analogy with the catastrophe theory of Thom [A38] in more detail.

- 1. Catastrophe map is the graph of solutions for the vanishing of the gradient of a potential function as a function of control parameters. One considers only real roots as function of variable control parameters and the number of real roots varies as a function of parameters and one obtains lower-dimensional regions at which the number of roots to catastrophe polynomial changes as roots become degenerate [A38, A19]. Cusp catastrophe serves as the school example.
- 2. In the recent case, space-time surfaces correspond to roots of complexified octonionic polynomials and the coefficients of the polynomial appear as control parameters. Also complex roots are allowed and real 4-D space-time surface is obtained as a real projection and mapped to H by $M^8 H$ duality and conjectured to correspond to a preferred extremal of an action determined by the twistor lift of TGD.
- 3. The basic motivations for this assumption are quantum criticality requiring preferred extremal property, which requires at the level of H the independence of the dynamics on coupling parameters of the twistor lift of Kähler action outside the loci of non-determinism demanded by M^8 level.

Connection between singularities and preferred extremals of various types

The above picture suggests the characterization of the space-time surfaces in terms of their singularities as surfaces of M^8 .

At the level of H one can consider 4 kinds of very simple preferred extremals, which give rise to prototype singularities.

- 1. Einsteinian spacetime $X^4 \subset M^8$ with a 4-D M^4 projection and a unique normal space as a point of CP_2 . $X^4 = M^4$ defines a prototype.
- 2. Cosmic string extremal $X^2 \times Y^2$ with Y^2 a complex surface in CP_2 and defining a set of normal spaces assignable to a point of X^2 . $M^2 \times S^2$, S^2 a geodesic sphere defines a proto type. S^2 can be either homological trivial or non-trivial.
- 3. $X^3 \times S^1 \subset M^4 \times CP_2$, where S^1 is a geodesic circle of CP_2 , is a candidate for a preferred extremal and singular surface. Both $M^3 \times S^1$ and $E^3 \times S^1$ are minimal surfaces and vacuum extremals of Kähler action.

For the Euclidean signature, X^3 could be space-like and define a 3-ball compactifying to S^3 as a sub-manifold of the S^6 brane. The very special moments t_n would be singular in the sense that the normal space at a given point of $X^3 \subset M^4 \subset M^8$ would not be unique and would give rise S^1 singularity.

4. CP_2 type extremal with light-like geodesic as $M^4 \subset H$ projection and corresponding to a light-like geodesic in M^8 with normal spaces forming a 3-D surface in CP_2 . Also $M^1 \times Y^3 \subset M^4 \times CP_2$ can be considered but is probably not a preferred extremal.

The intuitive picture is that these 4 types of preferred extremals correspond to singularities of the normal space of $X^4 \subset M^8$ of dimension d = 0, 1, 2, 4 and codimension $d_c = 4 - d$.

Analogy with knot theory

In knot theory a knot in 3-D space is projected to 2-plane where one obtains a diagram containing crossings. Knot invariants can be constructed in terms of this diagram. A knot theory inspired intuition is that space-time surfaces near to these special cases are projected to these special surfaces to get the toy model.

- 1. Canonically embedded $M^4 \subset M^8$ (or $M^4 \subset M^4 \times CP_2$) is an analog of the plane to which the knot is projected. One can project the space-time regions with 4-D M4 projection to M^4 . In particular, those with a Minkowskian signature of the induced metric.
- 2. The M^4 projection of CP_2 type extremal is 1-D light-like geodesic. One must project the deformations of CP_2 type extremals to CP_2 type extremal at the level of H. At the level of H, CP_2 type extremal could correspond to a light-like geodesic of M^8 such that each point of the geodesic is singular point such that the union of quaternionic normal spaces defines a 3-D quaternionic surface in CP_2 .

A puncture in E^3 as an infinitesimal hole serves as an analogy. At the puncture, one can say that all normal spaces labelled by points of S^2 are realized.

At the given point of the light-like geodesic, the quaternionic normal space of point is not unique but a 3-D union of normal spaces and defines a 3-D subset CP_2 .

3. For the $X^2 \times Y^2 \subset M^4 \times CP_2$ type cosmic string extremals and their small deformations, one must project to $M^2 \times S^2 \subset CP_2$. For a point of X^2 the normal spaces define $Y^2 \subset CP_2$ so that the singularity is milder.

For $X^3 \times S^1 \subset M^4 \times CP_2$ the normal spaces at a point of X^3 would define $S^1 \subset CP_2$. If X^3 is Euclidean, these 3-D singularities could correspond to the $t = t_n$ planes associated with the branes. The small deformations of these surfaces would project to $M^3 \times S^1$. This picture would integrate all 3 kinds of singularities and various types of preferred extremals to a single unified picture.

A toy model for the singularities

The following toy model for the singularities in the case of CP_2 type extremals generalizes also to other singularities.

1. A rather general class of CP_2 type extremals can be represented as a map $M^4 \to CP_2$ given by

$$m^k = p^k f(r) \quad ,$$

where p^k is light-like momentum and r is radial U(2) invariant CP_2 coordinate labelling 3-spheres of CP_2 such that $r = \infty$ gives homologically non-trivial geodesic 2-sphere instead of 3-sphere.

If f(r) approaches constant value for $r \to \infty$, one can say that M^4 time stops at this limit, and one obtains a homologically non-trivial geodesic sphere instead of 3-D surface identifiable as an intersection with 6-D brane. Various external particles of the vertex would correspond to $m^k = p_k f_i(r)$ such that their values at $r = \infty$ co-incide.

It is not possible to obtain omologically trivial 2-sphere in this manner.

2. Outside the vertex, the CP_2 type space-time sheets have distinct light-like geodesics as M^4 projections and they can be continued to distinct regions of M^4 in the toy model.

The analog of the knot diagram would be a set of M^4 :s with different constant values of CP_2 coordinates. The CP_2 type extremals would be glued along light-like geodesics to various M^4 s.

The CP_2 points of M^4 :s meeting at the same geodesic sphere must belong to the same geodesic sphere S^2 . The S^2 :s associated with different vertices are different. Note that any two geodesic spheres must have common points.

3. In the toy model for the string world sheets $X^2 \times Y^2$ would be projected to a piece of $M^2 \times S^2$ connecting two partonic vertices with the same S^2 . S^2 :s would be at the ends of the string, whose orbit is a piece of M^2 .

 $B^3 \times S^1$ could be interpreted as a subset of 6-D brane with B^3 identified as the $t = t_n$ cross section of M^4 light-cone.

This picture would suggest that the singularities could be indeed located to $t = t_n$ planes and integrated together to form a rough analog of catastrophe map.

Some examples of minimal surfaces with 1-D CP_2 projection

This subsection is not directly relevant to the basic topic and is added to give ideas about the possible role of volume term.

The original proposal was that preferred extremals are extremals of Kähler action but the twistor lift introduced the volume term as an additional term. This removed the huge vacuum degeneracy of Kähler action meaning that any 4-surface for which CP_2 projection was so called Lagrange manifold with the property that induced Kähler form vanishes, was a solution of field equations. For these surface induced Kähler potential is pure gauge.

The addition of the volume term removes this degeneracy and only minimal surfaces of this kind are possible as extremals. It is however not clear whether they are preferred extremals (are they analogs of complex surfaces?).

These solutions have not been studied previously [K14]. Space-time surfaces representing a warped embedding of M^4 with a flat metric represent the simplest example.

1. Denoting the angle coordinate of the geodesic sphere S^1 by Φ and the metric of S^1 by $ds^2 = -R^2 d\Phi^2$ the ansatz reads in linear Minkowski coordinates as $\Phi = k \cdot m$, where k is analog of four-momentum. The induced metric is flat and the second fundamental form vanishes by the linearity of Φ in m so that the field equations are satisfied.

Boundary conditions require the vanishing of the normal components of momentum currents and give $(\eta^{\alpha\beta} - R^2 p^{\alpha} p^{\beta})n_{\beta} = 0$. This condition cannot be satisfied so that these solutions should have infinite size, which looks unphysical.

The presence of the volume term in the action implies that the induced metric appears in the boundary conditions and this represents a problem quite generally. The only way to overcome the problem is that there are no boundaries. The many-sheetedness indeed makes this possible.

The warped extremals could represent a reasonable approximation of the space-time surface in the regions which are almost empty.

2. The light velocity defined in terms of time taken to get from the M^4 position A to B, is reduced to $c_1 = \sqrt{1 - |k \cdot k|}$. If k is light-like this does not happen.

Although the analog of gravitational force is vanishing in warped metric, the deviation the flat metric from M^4 metric given by $|k \cdot k|$ in flat case could it be interpreted as gravitational potential and the gravitational potential energy of test mass would be given by by $E_{gr} = -m|k \cdot k|$.

Could Nature provide a kind of cognitive representation or toy model of a gravitational field as a piecewise constant function in terms of CDs with which warped vacuum extremals would be associated? The representation would contain length scale dependent Λ as second parameter assigning momentum 4-momentum proportional to Λp^k to the CD. The volume energy would include its gravitational potential energy represented in terms of warping?

For warped solutions the space-time light cone - to be distinguished from its embedding space counterpart - would be defined by $c_1^2 t^2 - r^2 = 0$ and space-time CD would be modified accordingly.

Only single extremal - canonically embedded M^4 - remains from the spectrum of cosmological vacuum extremals for Kähler action having 1-D CP_2 projection and defined by $\Phi = f(a)$, where f is an arbitrary function of light-cone proper time coordinate $a = \sqrt{t^2 - r_M^2}$.

At QFT-GRT limit, the many-sheeted space-time is approximated with Einsteinian cosmology with the deviation of the induced metric from M^4 metric defined by the sum of the corresponding deviations for the sheets. Since the value of Λ becomes large in short p-adic length scales, a cosmology resembling GRT type cosmology could emerge and Einstein's equations would be a remnant of Poincare symmetry.

The induced metric for the solutions has very little to do with the metric appearing at the Einsteininian limit. The models of cosmology as space-time surfaces based on Kähler action with vanishing Λ could however make sense in very long scales for which Λ approaches zero.

For string dominated cosmology, the comoving mass is proportional to a [K119, K14, K77]. One has a silent whisper amplified to a Big bang in GRT sense. Also critical cosmology [K14] as an analog of inflationary cosmology for which curvature scalar as dimensional quantity vanishes can be regarded as a silent whisper amplified to a Big Bang and also it becomes Euclidean for a critical value $a = a_0$ of cosmic time.

4.7 Still about quantum measurement theory in ZEO

The relation between zero energy ontology (ZEO) based quantum measurement theory and adelic vision could be much clearer. The following considerations suggest a more precise picture about cognitive representations and formulation of quantum measurement theory for them.

In the sequel ZEO based theory of consciousness [L77, L112] as quantum measurement theory is discussed first by starting with a criticism of physicalism and after that introducing ZEO based view about consciousness as quantum measurement theory as a solution to the problems of physicalism.

After this the relation between zero energy ontology (ZEO) based quantum measurement theory and adelic vision [L74, L75] is discussed. The considerations suggest a more precise picture about cognitive representations and formulation of quantum measurement theory for them. One can generalize classical cognitive representations as number theoretical discretizations of space-time surfaces in the extension of rationals considered to their quantum counterparts as wave functions in the Galois group of the extension and introduce also fermions as spinors in the group algebra of Galois group. The strongest option is purely number theoretical representations of spinors as spinors in this group algebra. Presumably however M^8 spinors are required and have interpretation in terms of octonion structure.

An attractive vision is that number theoretical quantum measurements reduce to measurement cascades involving a sequence of state function reductions reducing the entanglement between wave functions in sub-Galois group H and group G/H and ends up to a prime Galois group for group algebra has prime dimension and represents Hilbert space prime not decomposable to tensor product.

Also time measurement is considered from the number theoretic perspective assuming $M^8 - H$ duality [L103]. Clock readings are realized as roots of the rational polynomial determining the space-time surface in M^8 . Time measurement would involve a localization to a definite extension of rationals, whose dimension n must be proportional to the temporal distance T between the tips of causal diamond (CD) to guarantee fixed time and energy resolution.

4.7.1 ZEO based theory of consciousness as quantum measurement theory

Consider first zero energy ontology (ZEO) based quantum measurement theory as a theory of consciousness.

Criticism of physicalism

It is good to start with a criticism of physicalism.

1. In physicalism consciousness would reduce to a physical property, like energy, momentum or charge and one would have the hard problem. There would be absolutely no idea why for instance sensory qualia emerge and how they correspond to sensory input. For instance, the assignment of sensory qualia to brain regions leads to a mystery: auditory, visual, etc. areas look exactly the same. How they can give rise to so different qualia?

Remark: The answer to the question is that this is not possible. I n TGD framework macroscopic quantum coherence and ZEO allow to assume that sensory qualia are seated at sensory organs [L65].

- 2. This is not the only problem: free will is not possible and we must stop talking about ethics and moral as we have indeed done in modern free market economy, which threatens to destroy our civilization.
- 3. The third problem of physicalism and also idealism is that conscious experience is about something: it carries information about something, external world, my body, even about my thoughts. It is associated with a pair of systems- me and the rest of the world - rather than single system as consciousness as a physical property implies. This "aboutness", kills the physicalistis view and actually idealism and under reasonable assumptions also dualism. Standard ontologies of consciousness fail.

Physicalistic approach has also problems with quantum measurement theory. The basic problems are basically due to the fact that observer as a conscious entity remains an outsider: observations affect the measured system but theory cannot say anything about observer as subjective entity. In ZEO the situation is different [L112] (http://tinyurl.com/wd7sszo).

- 1. Quantum jump defines the basic building brick of conscious experience. It is something between two different quantum worlds, not in the world as a physical property of quantum system. Consciousness is a moment of re-creation. This a solves the hard problem and problem of free will.
- 2. Also the paradox of state function reduction can be solved if one can understand the problems related to the notion of time. There are two times: experienced time and geometric time,

or the clock time. They are very different. Experienced time irreversible and has preferred moment "Now". Geometric time reversible and without preferred "Now". For some reason these times have been however identified.

ZEO based quantum measurement theory

In ZEO physical states as time= constant snapshots are replaced by pairs of "initial" and "final" states A and B or - by holography - with superpositions of deterministic time evolutions from A to B with respect to geometric time - note the analogy with computer program in computer science, behavior pattern in neuroscience, and function in biology.

- 1. In "small" state function reductions (SFRs) "weak" measurements the superposition of time evolutions from A to B is replaced with a new one such that states A at passive end "initial state" are not changed. Classical determinism is respected although one has quantum jump and generalization of quantum measurement theory. Two times two causalities. The temporal distance T between A and B increases in statistical sense and this gives the correspondence between experienced time as sequence of state function reductions and geometric time is identified as T. These measurements changing B correspond to "weak" measurements analogous to classical measurements and to sensory input. A represents permanent part of selfness, "soul" one might say.
- 2. In "big" (ordinary) state function reductions (BSFRs) the roles of "initial" and "final" states change and the arrow of geometric time changes. Self dies and reincarnates with an opposite arrow of geometric time.
- 3. In more precise view the pairs of time=constant snapshots are replaced with what I call causal diamonds (CDs). The assumption that the size of CD is preserved In BSFR as assumed originally leads to some paradoxical looking implications. For instance, the size of CDs assignable to our sub-selves identifiable as mental images would increase without bound. $M^8 H$ duality suggests strongly that the sizes of CDs can decrease in BSFR: the formerly active boundary would be frozen but the temporal distance of formerly passive boundary would be reduced so that the size of CD would decrease. One could say that self has childhood and starts from scratch with all sins of previous life forgiven.

This picture about state function reduction finds considerable empirical support.

- 1. The paradoxical experimental findings of Minev *et al* in atomic systems challenging standard quantum measurement theory give strong support for the reversal of the arrow of time in BSFR [L98] [L98] (http://tinyurl.com/yj9prkho).
- 2. Also Libet's finding that experience of free will [J15] seems to be preceded caused by neural activity, can be understood. It is not anymore support for the claim that free will is an illusion. State function reduction changing time order happens, and free will causes neural activity in the geometric past.
- 3. There is are lot of support for the new view about time from biology. For instance, selforganization - not only biological - could be understood as involving time reversal meaning that the time reversed reduction of order implied by generalization of second law looks from standard observer's viewpoint like increase of order. Self-assembly and generation of structures in long scales would involve increase of time order. Evolution is second aspect of self-organization and reduces to the unavoidable increase of h_{eff} as dimension for extension of rationals. Also the need for energy feed - metabolic energy feed in living matter - can be understood because the increase of h_{eff} keeping other parameters constant, increases energy scale. Dark matter would be visible everywhere in sharp contrast with standard prejudices.
- 4. There is support even from cosmology and astrophysics, where TGD predicts quantum jumps in macroscopic scales. For instance, stars older than Universe can be understood in more detailed picture about ZEO [L99, L101] (http://tinyurl.com/tf38xnx).

One can of course criticize the view about the role of clock time as the distance T between the tips of CD as over-simplified [L112].

1. The state function reductions preceding SSFRs are preceded by unitary processes U. What one can say about "time evolution" U. First of all, U is assumed to produce a zero energy state de-localized in the space of CDs - in particular with respect to the distance T between the tips of CD.

The simplest guess is that in SSFR a complete localization in T - measurement of T - and other moduli of CD (say boost with respect to the lower tip of CD) occurs. Can one reduce the localization in T to a SSFR reducing quantum entanglement or is time measurement something different? What entanglement of CD sizes with different values of T with the measurement apparatus could mean? What the presence of a measurement apparatus for time T - the clock at fundamental level, could mean mathematically? Later also the question whether one could reduce this measurement to pure number theory emerges?

2. The notion of completely localized state is over-idealization and also mathematically poorly defined. Gaussian wave packet over classical states with well-defined classical conserved energy (by Poincare invariance) with respect to T localized around some value T_0 is a more realistic notion and time measurement would mean localization to a wave packet around T_0 .

In [L112] the proposal that the time evolution of self could be seen an analog of cooling process analogous to cosmic cooling is considered. This would correspond to an adiabatic time evolution happening for a particle in box whose size increases slowly. In this process the coefficients in a superposition of states with given classical energy remain unaffected but the classical energies of the states themselves decrease. This would conform with Uncertainty Principle stating that the classical energies scale as 1/T.

A more detailed view about quantum measurement in ZEO

Consider next in more detail what state function as quantum measurement means in TGD.

- 1. In standard quantum measurement theory quantum measurements are often thought to be performed by humans only. In TGD one assumes that state function reduction as analog of quantum measurement is universal and can take place for any pair of mutually entangled systems unentangled from its complement.
- 2. Density matrix for the entangled pair of systems is the fundamental observable. This applies to both BSFRs and SSFRs at active boundary of CD, which correspond to "weak" measurements commuting with the observables diagonalized at the passive boundary of CD and thus leaving the states at it invariant.
- 3. Quantum measurement involves typically measurement of several observables. This is realized as a measurement cascade. First the quantum measurement of density matrix occurs for some pair formed sub-system S_1 and its complement S_2 forming together system S. After the same occurs for S_1 and S_2 . Observables correspond to density matrices in this cascade. One proceeds as along as new decompositions are found. If the final state belongs to a sub-space with prime dimension the cascade stops since there is no further decomposition to tensor product.
- 4. The density matrix for subsystem in general case decomposes to a sum of projectors t subspaces and the state function reduction takes to one of them. The outcome of the measurement can be sub-space rather than ray.

Number theoretic vision suggests also a second possibility. The SSFR would take place only if the eigenvalue of density matrix having probability interpretation associated with the subspace or ray is in the extension of rationals associated with the matrix elements of the density matrix and space-time surfaces considered (defining the cognitive representation). If one assumes frequency interpretation of probability theory, this probability must be rationals. Entanglement can be number theoretically stable. This would that one can have stable entanglement. It is natural to assume that BSFR can can increase the extension of rationals associated with the eigenvalues of density matrix in the extension of the extension associated with its matrix elements.

5. Stable entanglement could be crucial for quantum computation as also the possibility of large values of h_{eff} and of time reversal. One can also assign to entanglement with coefficients in an extension of rationals p-adic variant of entanglement entropy by replacing logarithms of probabilities with the logarithms of their p-adic norms. These p-adic entanglement negentropies can be positive so that the entanglement carries information. This negentropy is different from the real negative entropy due to the loss of precise knowledge about entangled states. Quite generally, the sum of p-adic negentropies can be larger than real entropy. This would explain the paradoxical looking fact that highly evolved biological systems are highly entropic [I114] [L37]. england

4.7.2 The relationship between adelic physics and ZEO based quantum theory

The challenge is to formulate quantum measurement theory taking into account the constraints from adelic physics [L74, L75]. One can consider the possibility is that the quantum physics could reduces at the level of cognitive representations to purely number theoretic physics. This would mean huge simplification. I have considered quantum theory at the level of cognitive representations from the point of view of number theory in [L109] and from the perspective of scattering amplitudes in [L108].

Two kinds of cognitive representations

One can consider two kinds of cognitive representations. The cognitive representations considered hitherto correspond to number theoretical discretization of space-time surface determined by an extension of rationals, they are "classical". The bosonic wave functions in Galois group of extension acting on cognitive representations and their fermionic counterparts based on fermionic dynamics in the group algebra of Galois group and its normal subgroups (Galois groups too) would define quantal cognitive representations.

- 1. There are cognitive representations both at the classical level in terms number theoretical discretizations of space-time surfaces defined by the extension of rationals and at the quantum level based on spinorial wave functions in Galois group of the representation. Also the spinorial wave functions in factor sub-groups and normal subgroups of Galois group are involved.
- 2. One can assign preferred primes p_{pref} to the classical space-time dynamics as ramified primes p_{ram} of the extension. For these the polynomial defining extension has double root in O(p) = 0 approximation. This would be the realization of quantum criticality for cognition: criticality is typically in potential models a situation in which two or more extrema of the potential function co-incide catastrophe theory of Thom is classical example.
- 3. At the level of state (spinorial) space wave functions in Galois group acting on cognitive representations are natural candidate for a bosonic state space. Quantum states would be wave functions in Galois group G with normal subgroup H acting as a Galois group of lower-D extension.

G/H is group itself and one can express wave functions in G as superpositions of products wave functions in G/H and H. The wave functions in G/H and H define naturally a tensor product and an attractive idea is that state function reduction can be regarded as measurement in G/H or equivalently in H. When H has prime order further reduction is not possible since Hilbert spaces with prime dimension are primes of tensor product.

A natural candidate for preferred primes p_{pref} is as orders of smallest possible normal subgroups of Galois group, kind of primitive generating Galois groups. **Remark**: One must consider also the possibility that quark and possibly also leptonic degrees of freedom are present as additional spinor indices. The fact that M^8 has octonionic structure could require also M^8 spinor structure.

4. In TGD dark matter is identified as $h_{eff} = n \times h_0$ phases of ordinary manner. *n* is identified as the order of Galois group of Galois extensions and thus of the extension itself. For ordinary value of Planck constant empirical inputs suggests the identification $h = 6h_0$ [L52, L84].

Quite interestingly, one has $6 = 2 \times 3$ so that there is factorization to 2-D and 3-D subspaces assignable to massless particles, and massive gauge bosons. This indeed suggests that number theoretical vision could allows to represent all many-particle states in terms of wave functions (spinor fields) in the group algebra of Galois group.

5. How to construct cognitive representations for fermions? A natural generalization of the bosonic dynamics in *n*-D group algebra of Galois group is introduction of spinor structure in terms of 2^k -dimensional spinors in the group algebra. For k = n both chiralities are present and for k = n - 1 only second chirality. In fact, one could pose even more chirality conditions giving $2^{n/2}$ -D ([n + 1]/2-D) spinors for even (odd) *n*. Indeed, the recent view about SUSY in TGD framework suggests that only quarks - second embedding space chirality - appear as fundamental fermions and that leptons are local composites of 3 quarks - spartners of quarks in well-defined sense [L113] (http://tinyurl.com/y4pdb2xz).

The simplest option is that at the level of cognitive representations the fermionic oscillator operator algebra corresponds to the oscillator operator algebra creating fermions states having at most k = n, k = n - 1,...n/2 ([n + 1]/2) fermions assignable to these spinors in finite measurement resolution. Entire quantum dynamics at the level of cognitive representations would reduce to the dynamics of fermions in the group algebra of Galois group and its Galois sub-groups.

6. There is also question about the Galois groups of the extensions of various p-adic number fields Q_p induced by the extension of rationals with dimension n. For p-adic numbers in approximation the extension reduces to a finite field G(p,k), $k \leq n$, and one has k-dimensional extension. Galois group G_p is smaller than the Galois group G for rationals. G_p would act naturally in the p-adic counterparts of cognitive representations and the representations of G would reduce to direct sums of representations of G_p . Note that the distinction between sensory and cognitive (real and p-adic) would emerge only at the quantum level.

For p < n+1 the fact that one has $x^{p-1} = 1$ for G(p) implies that the irreducible polynomial P defining the extension Q reduces to a polynomial with degree $nmodp-1 \le p-1$. Information is lost for p < n+1. For $p \ge n+1$ situation is different but also in this case the reduction occurs for ramified primes since polynomial P as in this case multiple roots. This would be the counterpart of quantum criticality at the level of cognitive representations.

7. Could the primes appearing as factors of n be preferred p-adic primes? Since these primes as p-adic primes mean a loss of information, they are distinguished but hardly preferred in p-adic evolution. Ramified primes larger than n are more plausible candidates and can be assigned even with polynomials of order 2. The preferred p-adic primes assignable to elementary particles are indeed large: electron would correspond to $M_{127} = 2^{127} - 1 \sim 10^{38}$ [K74].

Quantum measurement theory for cognitive representations

What can one say about quantum measurement theory for cognitive representations? The basic questions concern the tensor products. How many tensor factorizations there are and can one pose some conditions on them? Assume that fermionic Fock states for second quantized spinor fields in n-D group algebra are enough for quantum physics at the level of cognitive representations.

1. Tensor product decomposition for *n*-D group algebra corresponds to the factorization $n = k \times l$. All factorizations of *n* define a possible quantum measurement situation and state function reduction can take place in bosonic sector to *k* or equivalently *l*-dimensional space. These factorizations would be highly unique since they correspond to pairs of Galois group *G* and its Galois subgroup *H*. They are defined modulo discrete automorphism of *G*. It is

not clear whether the choice of this automorphism has physical content: one might consider a discrete variant of gauge invariance.

For the fermionic oscillator algebra analogous statement holds true. Now the decompositions are induced by $n = k \times l$ decompositions.

2. State function reduction cascades would correspond to sequences of Galois subgroups $G \supset G_1 \supset \dots G_k$ such that G_k corresponds to either trivial group of group with prime order. In this case the final state would be reached by a factorization in which the density matrix for G_k does not allow eigenvalues in the extension considered. This extension could be G, G_1 or perhaps rationals (frequency interpretation for probabilities).

$M^8 - H$ duality and measurement cascade

- $M^8 H$ duality [L103] suggests much more concrete picture about the measurement cascade.
 - 1. $M^8 H$ duality predicts that the roots r_n of a rational polynomial defining the space-time surfaces at the level of M^8 correspond "very special moments in the life of self" $t = r_n$ for the M^4 linear time in the rest system of CD, and that once these moments have been experienced, BSFR can take place. This is possible but not the only possible interpretation.
 - 2. $M^8 H$ duality and the view about evolution as analog of genetic evolution in which geness are conserved suggests that the polynomials can be regarded as functional composites of simple polynomials $P = P_{n_1} \circ P_{n_2} \circ \dots P_{n_k}$ satisfying $P_{n_r} = 0$ (n_i refers to the degree of the polynomial). P possesses the roots of P_i and the corresponding Galois groups as normal subgroups as the counterpart for the conservation of genes in evolution.

One can distinguish also primitive polynomials as those defining extensions which do not decompose further. Galois groups with prime number of elements corresponds to such extensions. Note that the same extension can appear at several levels in hierarchy and would correspond to a realization of extension at different hierarchy level defining a kind of abstraction level.

3. Intuitively the measurement cascade should correspond to a cascade proceeding to shorter time and length scales by increasing the resolution and also to a process in which abstraction is gradually concretized.

Could the measurement cascade for a state localized to a given extension of rationals start with the measurement of the root set $X_1 = \{r_{1,1}\}$ of P_{n_1} corresponding to the lowest time resolution. After than P_2 and the root set $X_2 = \{r_{2,i}\}$ would be measured meaning a refined of time resolution replacing $r_{1,i}$ with as subset of X_2 around it.

Here one must be however very cautious: one could also consider a hierarchy of CDs with decreasing size scales as the counterpart of the measurement cascade. I do not understand well enough the scale hierarchy to answer the question whether these two views might relate.

Measurement of time number theoretically

Could the measurement of clock time T as (average) distance between the tips of CD [L112] be understood as number theoretical measurement?

1. What about the measurement of time as the distance T between tips of CD or more generally as the center of mass value T_0 of T in the case that one has Gaussian wave packets localized around varying T_0 ? How could one realize the measurement apparatus - the clock - in terms of entanglement?

Suppose that the superposition over CDs with different values of T corresponds at the level of space-time surfaces in M^8 to that for space-time surfaces determined by polynomials P_n with varying degrees and rational coefficients. The measurement fixing the extension and Galois group would not fix P_n since there is a large number of polynomials with rational coefficients but same Galois group. The measurement fixing the extension leads to a partial (at least) localization in T or T_0 but this is not expected to be enough.

2. A stronger localization in the state function reduction measuring n would require that T or T_0 correlates with the degree n. How could this be achieved in a natural manner? Intuitively the requirement of some fixed time resolution based on the preferred moments $t = r_n$ interpreted as clock readings has fixed resolution as the average time lapse $\Delta T = \langle \Delta T_{i,i+1} = r_{i+1} - r_i \rangle$ would require $n \propto T$ or $n \propto T_0$. How could this be achieved concretely? Could one specify the zero energy states by giving the time resolution as ΔT and being equivalent to energy resolution. This would also dictate the resolution of the cognitive representation as the set of space-time points in the extension.

4.8 The dynamics of SSFRs as quantum measurement cascades in the group algebra of Galois group

Adelic physics [L73, L74] is a proposal for the physics of both sensory experience having real physics as correlate and cognition having various p-adic physics as correlates. Adele is a book-like structure formed by real numbers and the extensions of p-adic number fields induced by a given extension of rationals with the pages of the book glued together along its back consisting of numbers belonging to the extension of rationals. This picture generalizes to space-time level. Adelic physics relies on the notion of cognitive representation as unique number theoretic discretization of the space-time surface. This discretization has also fermionic analog in terms of spinor structure associated with the group algebra of the Galois group of extension.

Adelic physics, $M^8 - H$ duality, and zero energy ontology lead (ZEO) to a proposal that the dynamics involved with "small" state function reductions (SSFRs) as counterparts of weak measurements could be basically number theoretical dynamics with SSFRs identified as reduction cascades leading to completely un-entangled state in the space of wave functions in Galois group of extension of rationals identifiable as wave functions in the space of cognitive representations. As a side product a prime factorization of the order of Galois group is obtained.

The result looks even more fascinating if the cognitive dynamics is a representation for the dynamics in real degrees of freedom in finite resolution characterized by the extension of rationals. If cognitive representations represent reality approximately, this indeed looks very natural and would provide an analog for adele formula expressing the norm of a rational as the inverse of the product of is p-adic norms.

4.8.1 Adelic physics very briefly

Number theoretic vision leading to adelic physics [L73] provides a general formulation of TGD complementary to the vision [K109] (http://tinyurl.com/sh42dc2) about physics as geometry of "world of classical words" (WCW).

- 1. p-Adic number fields and p-adic space-time sheets serve as correlates of cognition. Adele is a Cartesian product of reals and extensions of all p-adic number fields induced by given extension of rationals. Adeles are thus labelled by extensions of rationals, and one has an evolutionary hierarchy labelled by these extensions. The large the extension, the more complex the extension which can be regarded as n-D space in K sense, that is with K-valued coordinates.
- 2. Evolution is assigned with the increase of algebraic complexity occurring in statistical sense in BSFRs, and possibly also during the time evolution by unitary evolutions and SSFRs following them. Indeed, in [L121] (http://tinyurl.com/quofttl) I considered the possibility that the time evolution of self in this manner could be induced by an iteration of polynomials at least in approximate sense. Iteration is a universal manner to produce fractals as Julia sets and this would lead to the emergence of Mandelbrot and Julia fractals and their 4-D generalizations. In the sequel will represent and argument that the evolution as iterations could hold true in exact sense.

Cognitive representations are identified as intersection of reality and various p-adicities (cognition). At space-time level they consist of points of embedding space $H = M^4 \times CP_2$ or M^8 $(M^8 - H$ duality [L67, L68, L69] allows to consider both as embedding space) having preferred coordinates - M^8 indeed has almost unique linear M^8 coordinates for a given octonion structure.

3. Given extension of given number field K (rationals or extension of rationals) is characterized by its Galois group leaving K - say rationals - invariant and mapping products to products and sums to sums. Given extension E of rationals decomposes to extension E_N of extension E_{N-1} of ... of extension E_1 - denote it by $E \equiv H_N = E_N \circ E_{N-1} \dots \circ E_1$. It is represented at the level of classical space-time dynamics in M^8 (http://tinyurl.com/quofttl) by a polynomial P which is functional composite $P = P_N \circ P_{N-1} \circ \dots \circ P_1$. with $P_i(0) = 0$. The Galois group of G(E) has the Galois group $H_{N-1} = G(E_{N-1} \circ \dots \circ E_1)$ as a normal subgroup so that $G(E)/H_{N-1}$ is group.

The elements of G(E) allow a decomposition to a product $g = h_{N-1} \times h_{N-1} \times ...$ and the order of G(E) is given as the product of orders of H_k : $n = n_0 \times ... \times n_{N-1}$. This factorization of prime importance also from quantum point of view. Galois groups with prime order do not allow this decomposition and the maximal decomposition and are actually cyclic groups Z_p of prime order so that primes appear also in this manner.

Second manner for primes to appear is as ramified primes p_{ram} of extension for which the padic dynamics is critical in a well-defined sense since the irreducible polynomial with rational coefficients defining the extension becomes reducible (decomposes into a product) in order O(p) = 0. The p-adic primes assigned to elementary particles in p-adic calculation have been identified as ramified primes but also the primes labelling prime extensions possess properties making them candidates for p-adic primes.

Iterations correspond to the sequence $H_k = G_0^{\circ k}$ of powers of generating Galois groups for the extension of K serving as a starting point. The order of H_k is the power n_0^k of integer $n_0 = \prod p_{0i}^{k_i}$. Now new primes emerges in the decomposition of n_0 . Evolution by iteration is analogous to a unitary evolution as ex^{iHt} power of Hamiltonian, where t parameter takes the role of k.

- 4. The complexity of extension is characterized by the orders n and the orders n_k as also the number N of the factors. In the case of iterations of extension the limit of large N gives fractal.
- 5. Galois group acts in the space of cognitive representations and for Galois extensions for which Galois group has same order as extensions, it is natural do consider quantum states as wave functions in G(E) forming *n*-D group algebra. One can assign to the group algebra also spinor structure giving rise to $D = 2^{M/2}$ fermionic states where one has N = 2M or N = 2M + 1). One can also consider chirality constraints reducing D by a power of 2. An attractive idea is that this spinor structure represents many-fermion states consisting of M/2 fermion modes and providing representation of the fermionic Fock space in finite measurement resolution.

4.8.2 Number theoretical state function reductions as symmetry breaking cascades and prime factorizations

The proposed picture has very important quantal implications and allows to interpret number theoretic quantum measurement as a number theoretic analog for symmetric breaking cascade and also as a factorization of an integer into primes.

- 1. The wave functions in G(E) elements of group algebra of G(E) can be decomposed to tensor products of wave functions in $G(E)/H_{N-1}$ and H_{N-1} : these wave functions in general represent entangled states. One can decompose the wave functions in H_{N-1} in similar manner and the process can be continued so that one obtains a maximal decomposition allowing no further decomposition for any factor. These non-decomposable Galois groups have prime order since its group algebra as Hilbert space of prime dimension has no decomposition into tensor product.
- 2. In state function reduction of wave function G(E) the density matrices associated with pairs $G(E)/H_{N-1}$ and H_{N-1} are measured. The outcome is an eigenstate or eigen-space and gives

rise to symmetry breaking from $G(E) \equiv H_N$ to $E_N \times H_{N-1}$. The sequence of state function reductions should lead to a maximal symmetry breaking corresponding to a wave function as a produce of those associated with Galois groups of prime order. This define a prime factorization of the dimension n of Galois group/extension to $n = \prod_{i=1}^{N} p_i^k$! The moments of consciousness for self would correspond to prime factorizations! Self would be number theoretician quite universally!

Also also the fermionic cognitive representation based on finite-D Fock states defined by spinor components of G(E) is involved. The interpretation of Fock state basis as a basis of Boolean algebra in TGD: the spinor structure of WCW could be representation for Boolean logic as a "square root" of Kähler geometry of WCW. Cognition indeed involves also Boolean logic.

4.8.3 SSFR as number theoretic state function reduction cascade and factorization of integer

A highly interesting unanswered question is following. "Small" state function reductions (SSFRs) define the life cycle of self as their sequence. What are the degrees of freedom where SSFRs occur?

- 1. SSFRs take place at the active boundary of CD which shifts in statistical sense towards future in the sequence of state function reductions. State at the passive boundary is not changed.
- 2. The idea that quantum randomness could correspond to classical chaos (or complexity) associated with the iteration of polynomials (Mandelbrot and Julia fractals) [L121] led to reconsider the hypothesis that the polynomial representing space-time decomposes to a product $P = P_2(T - r) \times P_1(r)$. T corresponds to the distance between the tips of CD and r = tto the radial coordinate of M^4 assignable to the passive boundary of CD and equal to time coordinate t. $P_i(0) = 0$ is assumed to hold true.

 P_2 would change in SSFRs whereas P_1 and state at passive boundary would not. SSFRs (analogous to so called weak measurements) at active boundary would give rise to sensory input and various associations - Maya in Eastern terminology. P_1 would correspond to the unchanging part of self - "soul" or real self as one might say.

I was also led to consider a simplified hypothesis that P_2 is obtained as iteration $P_2 = Q_1^{\circ n}$ in *n*:th *n* unitary evolution preceding SSFR. One would start from some iterate $Q_1^{\circ k}$. This would reduce quantum dynamics to iteration of polynomials and to a deep connection with Mandelbrot and Julia fractals but it was quite clear why this would be true.

3. The mere factorization $P = P_2 \times P_1$ implies that the Galois groups associated with active and passive boundary of CD commute and number theoretic state function reduction cascade for the wave functions in G(E) for the extension determined by P_2 at active boundary could correspond to SSFR. Or course, also other commuting degrees of freedom are possible but number theoretic degrees of freedom could be the most important degrees of freedom involved with SSFRs.

4.8.4 The quantum dynamics of dark genes as factorization of primes

Gene level provides a fascinating application of this picture.

This contribution was inspired by discussion with Bruno Marchal about his with title "Do the laws of physics apply to the mind?" (https://tinyurl.com/ycls2bpt). Bruno Marchal is a representative of computationalism, which might be called idealistic and Bruno believes that physics follows from computationalism. The somewhat mystical notion of self-reference is believed to lead to consciousness. I do not share this view. The gist of the posting comes towards end where I describe how computationalism generalizes to quantum computationalism in TGD generalizing also the notion of quantum computation. What conscious problem solving is? This is the question to be discussed.

1. As found, dark photons and dark protons forming DNA codons as triplets could correspond to triplet representations for prime factor Z_3 of Galois group of Z_6 . Codon and conjugate codon could in turn correspond to the prime factor Z_2 of Galois group Z_6 so that double strand would correspond to Z_6 suggested by findings of Mills [L52] and TGD inspired model color vision [L84].

- 2. DNA codons could correspond to extension with Galois group Z_3 , and one can consider an entire hierarchy of extensions of extensions of ... extensions with dimensions n_i satisfying thus $n = \prod_{i=1}^{N} n_i$ and having Z_6 as subgroup at the lowest level of the hierarchy. The number N of factors would be the number of polynomials in the functional composition and thus define a kind of abstraction levels (abstractions are thoughts about thoughts about..., maps of maps of ...). N is expected to increase in evolution.
- 3. Could this abstraction hierarchy be realized at gene level? Genes decompose into transcribed regions exons and introns. Could different decomposition of genes to exons and introns correspond to different values of N and n_i and to different Galois groups. Could genes themselves form larger composites?

Could genomes form even large structures such as chromosomes with larger Galois groups. Years ago I considered the possibility of a collective gene expression based on the collective MB of organelle, organ, or even population: could this correspond to an extension associated with several genomes?

- 4. Could SSFR correspond to a sequence of symmetry breakings for the Galois groups of these structures decomposing them to sub-groups? Number theoretic interpretation would in terms of decompositions of integers to primes! Genome would be a quantum computer performing number theory!
- 5. Metabolic energy feed would increasing h_{eff} would also increase the orders $n_i = h_{eff}/h_0$ of the extensions appearing in the composition of extensions and thus the orders of polynomial factors P_i in the functional composite defining the extensions. Therefore the decompositions would be dynamical.

Metabolic energy feed requires BSFR changing the arrow of time if metabolic energy feed is actually feed of negative energy to environment. The emergence of a new prime factorization would require BSFR. That the time evolution by iterations would not require BSFR would support the proposal that time evolution by BSFRs could be induced by iteration dynamics for the polynomial P_2 assignable to the active boundary of CD.

4.8.5 The relationship of TGD view about consciousness to computationalism

This text was inspired by discussion with Bruno Marchal about his with title "Do the laws of physics apply to the mind?" (https://tinyurl.com/ycls2bpt). Bruno Marchal is a representative of computationalism, which might be called idealistic and Bruno believes that physics follows from computationalism. The somewhat mystical notion of self-reference is believed to lead to consciousness.

I do not share this view. The gist of the posting comes towards end where I describe how computationalism generalizes to quantum computationalism in TGD generalizing also the notion of quantum computation. What conscious problem solving is? This is the question to be discussed.

To my view computationalism is one of the failed approaches to consciousness - it cannot cope with free will for instance. It however contains an essential aspect which is correct: the idea of deterministic program leading from A to B. Problem solving be can regarded as attempt to find this program. You fix A as initial data and try to find a program leading from A to a final state characterized by data B. The program has duration T and can be very long and it is not clear whether it exists at all. You try again and again and eventually you might find it. In the real conscious problem solving this process means making guesses so that the process cannot be deterministic.

What does this view about problem solving correspond to in ZEO? We have states A and B represented as quantum states and we try to find quantum analog of classical program leading from A to B in some time T which can be varied.

1. A and B are realized as superpositions of 3-surfaces and fermionic states at them - located at time values t=0 and t=T. T can vary. Can we find by varying T a (superposition of) deterministic time evolution(s) - preferred extremal(s) (PE) - connecting A and B?

In ZEO and for fixed A and T PE in general does not exist. In ideal situation (infinite measurement resolution) and for given A and T, B is unique if it exists at all. One has analog of Bohr orbit and the quantum analog of classical program as the superposition of Bohr orbits starting from A and hopefully leading to B as a solution of the problem.

Remark: These superpositions can be regarded as counterparts of functions in biology and behaviors in neuroscience. The big difference to standard physics is that time=constant snapshot in time evolution of say bio-system is replaced with quantum superposition of very special time evolutions - PEs. Darwinian selection of also behaviors in biology correlates strongly with this.

2. So: given A and B, we try to find a value of T for which superposition of PEs from A to B exists. This would be the quantum program leading from A to B, and solving our problem.

Actually, not only ours, universe is full of conscious entities solving problems at various levels of self hierarchy. This takes place by a sequences of "small" SFRs (SSFRs, weak measurements) increasing T in statistical sense and replacing the state at B with a new one determined by state A for given value of T. At the level of conscious experience this is sensory perception and all that which is associated with it.

Finding the solution is analogous to the halting of quantum Turing machine by ordinary state function reduction, which corresponds in ZEO to a "big" (ordinary) SFR (BSFR). This would mean death in universal sense and reincarnation with reversed arrow of time in ZEO? Or is BSFR and death failure to solve the problem? I cannot answer.

Remark: The notion of self-reference is replaced with much more concrete notion of becoming conscious of what one was conscious of before SSFR. SSFR indeed gives rise to conscious eperience and one avoids the infinite regress associated with genuine self-reference. As an additional bonus one obtains evolution since the extension of rationals characterizing space-time surfaces can increase meaning higher level of consciousness. At the limit algebraic numbers the cognitive representation is dense subset of space-time surface.

3. Also finite measurement resolution and discreteness characterizing computation emerge from number theory.

To be a solution classically means that the 3-surface(s) representing B to have fixed discrete cognitive representation given by finite number of embedding space points in the extension of rationals defining the adele. Quantally, quantum superpositions of these points with fixed quantum numbers represent the desired final state.

Also Boolean logic emerges at fundamental level as square root of Kähler geometry one might say. Many-fermion state basis defines a Boolean algebra and time evolution for induced spinors is analogous to truth preserving Boolean map in which truths code for infinite number of conservation laws associated with symmetries of WCW.

4. How to find the possibly existing solution at given step (unitary evolution plus SSFR) with t=T? One performs cognitive quantum measurements at each step represented by SSFR. They reduce to cascades of quantum measurements for the states in the group algebra of Galois group - call it Gal - of Galois extension considered.

Gal has hierarchical decomposition to inclusion hierarchy of normal subgroups implying the representation of states in group algebra of Gal as entangled states in the tensor product of the group algebras of normal sub-groups of Gal. The hope is that this Galois cascade of SFRs produces desired state as an outcome and one can shout "Eureka!".

4.9 Questions related to the notion of self and time

The notion of self and the relation between subjective and geometric time involves unclear aspects. In the following I try to articulate the problematic issues as clearly as possible.

- 1. The precise nature of the hierarchy of causal diamonds (CDs) as correlate of self hierarchy should be characterized. The basic prediction that sub-selves have also time reversed variants should be interpreted and one can ask whether sensory-motor dichotomy is a sensible interpretation.
- 2. Are sub-selves always experienced as mental images and whether after images really represent re-incarnations of sub-selves.
- 3. Can the rather dramatic prediction of re-incarnations be transformed to an experimentally testable predictions. If one takes seriously the notion of self hierarchy and identifies the EEG correlates of self in a way proposed by Fingelkurts brothers [L27], this kind of prediction is possible.

4.9.1 Hierarchies of causal diamonds and space-time surfaces as geometric correlates for self hierarchy

CDs are obtained from the intersections of future and past directed light-ones by replacing their points with CP_2 : as a matter fact, CP_2 plays no active role in the definition. I have not been able to nail down the precise definition for the hierarchy of causal diamonds. Self hierarchy demands that CDs serving as embedding space correlates for selves have sub-CDs identifiable as mental images of self. The basic question is whether CDs can also overlap. If so then finite unions of CDs could be allowed.

Selves as conscious entities are assumed to have space-time surfaces within CDs as spacetime correlates. These CDs are dynamical: the other boundary remains unaffected during sequence of repeated state function reductions as also the states at it. Second boundary shifts so that the distance between the tips of CD increases and defines the experienced flow of time. These spacetime surfaces form also a hierarchy. One could consider also a more precise identification of self. By SH string world sheets and/or partonic 2-surfaces or their light-like orbits could serve as space-time correlates of selves. The orbit of partonic 2-surface is indeed analogous to nervous system residing at the boundary between internal (Euclidian) and external (Minkowskian) worlds.

Given space-time surface has both Minkowskian and Euclidian regions - wormhole contacts separated by wormhole throats at which the signature of the induced metric changes. Minkowskian space-time sheets are connected by extremely short CP_2 sized Euclidian wormhole contacts and in GRT-standard model approximation are approximated by single GRT space-time. If the magnetic flux through wormhole contact is monopole flux, the wormhole contact connecting two Minkowskian space-time sheets has interpretation as a building brick of elementary particles. Minkowskian space-time sheets at different levels of hierarchy are disjoint and separated by Euclidian wormhole contacts. This forces to modify the notion of quantum mechanical subsystem as a tensor factor of the state space.

What is new that two Minkowskian space-time sheets glued to larger disjoint Minkowskian space-time sheets can be connected by magnetic flux tube serving as a correlate for (negentropic) entanglement just as wormholes in ER-EPR proposal of Maldacena and Susskind [B20, B21] (see http://tinyurl.com/y7za98cn) serve as correlates for maximal entanglement between blackholes. Two unentangled systems can therefore have subsystems, which are entangled and correspond to two space-time sheets connected by magnetic flux tubes! This is possible only in many-sheeted space-time and the hypothesis has been that two selves, which have no entanglement at their own level of self-hierarchy, can have entangled subselves and that this negentropic entanglement (NE) means sharing of mental images giving rise to a kind of stereo consciousness. The fusion of right and left visual fields would be example of stereo consciousness. Stereo conscious communication the mental images of two selves would fuse temporarily to single mental image by the reconnection of magnetic flux tubes. This reconnection would make possible also directed attention.

What does this situation mean at the level of CDs? It would seem that the CDs associated with selves sharing mental images overlap and that the space-time surfaces assignable to fused mental images/subselves belong to the intersection of CDs. Thus it seems that one must allow unions of also overlapping CDs.

4.9.2 Are time reversed sub-selves always experienced as mental images?

In the proposed vision about self as generalized Zeno effect self dies as the first state function reduction to the opposite boundary of CD takes place. This implies the re-incarnation of self with the property that the geometric time flows in opposite direction since the opposite boundary of CD shifts such that the temporal distance between it and the opposite static boundary increases in repeated state function reductions leaving the states at static boundary un-affected.

Subselves correspond to mental images. The question is whether self really experiences the time reversed sub-selves as a mental image and if this is the case, what can one conclude about this. For sub-sub-selves this problem is not acute if sub-sub-selves are experienced as kind of statistical averages.

A possible interpretation for self and its time reversal is in terms of sensory input and motor action. I have indeed proposed that motor action is essentially sensory experience in reversed time direction and Libet's discovery [J15] that conscious decision is preceded by neural activity (with respect to geometric time) provides a support for this interpretation. The time reversal of sensory mental image would represent motor action and at the level next below our level of hierarchy would be directly experienced as volitional act.

I have considered also other interpretations. One is suggested by visual illusion in which the picture of dancer is experienced to make either right or left pirouette. The direction of rotation would distinguish between mental images and its time reversal. It however seems that the sensory-motor dichotomy provides the most plausible and economical interpretation.

One can also wonder what happens, when mental the image is associated with a boundary of CD_1 , which overlaps with CD in such a way that the opposite boundary is outside of CD. Does self experience the mental image associated with CD but not its time reversal?

4.9.3 Re-incarnation and EEG

It is amusing how fast the attitudes change as ideas evolve and experimental data emerge. Only few years ago I could not say anything definite about reincarnation in the framework of TGD inspired theory of consciousness. Now it has become an unavoidable prediction of ZEO, which itself is a "must" in TGD framework.

The prediction related to re-incarnation is however not quite what one might have expected. In death of self a reincarnation as time reversed conscious entity takes place. For time reversed self subjective time evolution corresponds to evolution in a reverse direction of geometric time. The next death/reincarnation after this re-incarnation gives rise to a self for which the arrow of geometric time is the original one.

Can one test this prediction? If one accepts the predicted fractal self hierarchy in which sub-selves correspond to mental images of self, this is possible. I am too lazy to retype basics about ZEO, CDs, and about how self as generalized Zeno effect emerges and just assume that reader knows the basic concepts or sees to trouble to refresh her knowledge about them.

- 1. Self hierarchy predicts that also our mental images are conscious entities. Motor-sensory dichotomy naturally corresponds to sub-self and time reversed sub-self. That is sensory mental image and that associated with motor action induced by sensory input. Motor action initiated in the geometric past at the opposite boundary of CD (this explains Libet's finding that conscious decision is preceded by neural activity in geometric time). Note that motor action does not proceed from brain to muscles but in reversed time direction from muscles to brain! This conforms with the vision in which magnetic body is intentional agent.
- 2. To proceed one must identify EEG correlates for the sub-selves (mental images) and their time reversed re-incarnates. Here the work of Fingelkurts brothers (see http://tinyurl. com/jpszfpy) working in Finland helps [L27]. They postulate what they call operational architecture of brain (OA) having operations (O) and operational modules (OM) as building bricks. Quasi-stationary EEG segments are assumed to serve as correlates for operations and synchrony of these segments associated with various locations in brain tells that they belong to the same OM.

Synchrony means spatio-temporal coherence - not only spatial - and is very natural concept in ZEO, where 4-D CDs and space-time surfaces inside them serve as geometric correlates of selves. Synchrony implies that these EEG segments at different spatial locations begin and end at the same time. Between EEG segments there is rapid transition period (RTP) allowing to distinguish segments from each other. Quasi-stationary segments of EEG have average duration is about .3 seconds.

The translation of this picture to TGD framework is rather straighforward. Operations correspond to sub-selves and OMs to collections of them forming sub-selves of self. CDs (sub-CDs) in turn serve as geometric correlates for selves (sub-selves). The quasi-stationary segments of EEG become correlates for sub-selves/mental images. Operational module corresponds to a self/CD having sub-selves/sub-CDs with synchronous EEG segments. The average duration of mental image would be about .3 seconds.

Two sub-sequent quasi-stationary segments separated by RTP would correspond to sub-self and its re-incarnation in the original time direction. Note that a very brief period of geometric time defined by the duration of RTP identifiable as the duration of a unitary time evolution between two sub-sequent state function reductions at the same boundary of CD corresponds to a finite duration of experienced time - the lifetime of the time reversed mental image!

The testable prediction is that the segment corresponding to time-reversed sub-self is located in geometric past and runs in opposite direction of geometric time. This EEG segment should be assignable to motor response accompanying sensory mental image. This is a highly nontrivial prediction testing the new view about time.

3. One can check whether these EEG segments appear as pairs with first member assignable to sensory mental image and second one to motor mental image. Time reversal implies that second law is obeyed in "wrong" time direction for EEG segment assignable to the motor output and this can be tested. Already Fantappie [J82] discovered that both directions of (geometric) time appear in living matter and introduced the notion of syntropy as time reversal of entropy. Spontaneous molecular self-assembly is a basic example of a syntropic process and identifiable as a decay process in reverse direction of geometric time. Phase conjugation is known to occur for phase conjugate laser light and sound. Does a process analogous to self-assembly occur for segments of EEG associated with motor actions: is the motor part of EEG time reversed? To answer this question one needs phase information about EEG besides power spectrum. In principle this information is contained in EEG.

4.9.4 After images as reincarnations of mental images?

After images (see http://tinyurl.com/kevnzgq) appear periodically as one can easily find by looking and lamp and closing eyes. They also change colors. Could these after images be interpreted as re-incarnations? This sounds attractive but one must be very careful. A sub-self S, which dies and transforms to its time reversal S_1 reincarnates eventually as sub-self S_2 with the original arrow of time. According to the assumption about first reduction to opposite boundary made S_2 emerges at time later than S died and this conforms with what is known. The time interval between two subsequence after images would give information about the average value of Δt . The after images need not be identical copies of the original and their color indeed changes.

An alternative interpretation is that after images are not re-incarnations but belong to a 4-D population of sub-selves. Our geometric past is alive and changes all the subjective time. This is not so confusing when one realize that ZEO means that conscious existence is essentially 4-dimensional. Also our memories are dynamical and change all the subjective time. Negative energy signals to geometric past which correspond to time reversed sub-selves indeed affect the geometric past and memory representations. In principle this kind of signalling could be carried out artificially to manipulate geometric past.

4.9.5 Re-incarnation and time reversed selves as basic predictions of TGD inspired theory of consciousness

Life has been hard for skeptics during last two decades. A typical skeptic has as building bricks of his ego the items in the list of notions that they regard as pseudoscientific. This allows to attack

the people who have the gift of imagination and passion for genuine understanding, which skeptics unfortunately do not possess. What makes attacks easy that no arguments based on contents are needed and the skeptic need not waste his time by trying to understand the arguments of the person to be labelled as pseudoscientist or crackpot.

The typical rhetoric tricks used begin from replacement of Dr X with Mr X and end up with the "conclusion" that the work of Mr X is totally incomprehensible. I have learned that rather often skeptic of this kind is an academic dropout who never managed to do his MsC. Obviously, the role of skeptic became a way to survive socially and retain the illusion "I am a scientist". During last decades the list of pseudoscientific notions has shortened item by item as quantum biology and quantum consciousness have emerged as respected branches of science. The notion of re-incarnation (see http://tinyurl.com/jfpowqg) has been certainly regarded as one of safest pillars supporting the ego of skeptic but even this pillar is in danger to fall down. Poor skeptics.

It is indeed amusing how fast the attitudes change as ideas evolve and experimental data emerge. Only few years ago I could not say anything definite about reincarnation in the framework of TGD inspired theory of consciousness. Now it has become an unavoidable prediction of zero energy ontology (ZEO), which itself is a "must" in TGD framework.

Reincarnation: a testable prediction?

The prediction related to re-incarnation is however not quite what one might have expected. In death of self a reincarnation as time reversed conscious entity takes place. For time reversed self subjective time evolution corresponds to evolution in a reverse direction of geometric time. The next death/reincarnation after this re-incarnation gives rise a mental image for which the arrow of geometric time is the original one.

Can one test this prediction? If one accepts the predicted fractal self hierarchy in which sub-selves correspond to mental images of self, this is possible. I am too lazy to retype basics about ZEO, CDs, and about how self as generalized Zeno effect emerges and just assume that reader knows the basic concepts or sees to trouble to refresh her knowledge about them.

- 1. Self hierarchy predicts that also our mental images are conscious entities. Motor-sensory dichotomy naturally corresponds to sub-self and time reversed sub-self. That is sensory mental image and that associated with motor action induced by sensory input. Motor action initiated in the geometric past at the opposite boundary of causal diamond (CD) (this explains Libet's finding that conscious decision is preceded by neural activity in geometric time). Note that motor action does not proceed from brain to muscles but in reversed time direction from muscles to brain! This conforms with the vision in which magnetic body is intentional agent.
- 2. To proceed one must identify EEG correlates for the sub-selves (mental images) and their time reversed re-incarnates. Here the work of Fingelkurts brothers (see http://tinyurl. com/jpszfpy) working in Finland helps [L27]. They postulate what they call operational architecture of brain (OA) having operations (O) and operational modules (OM) as building bricks. Quasi-stationary EEG segments are assumed to serve as correlates for operations and synchrony of these segments associated with various locations in brain tells that they belong to the same OM.

Synchrony means spatio-temporal coherence - not only spatial - and is very natural concept in ZEO, where 4-D CDs and space-time surfaces inside them serve as geometric correlates of selves. Synchrony implies that these EEG segments at different spatial locations begin and end at the same time. Between EEG segments there is rapid transition period (RTP) allowing to distinguish segments from each other. Quasi-stationary segments of EEG have average duration is about .3 seconds.

The translation of this picture to TGD framework is rather straighforward. Operations correspond to sub-selves and OMs to collections of them forming sub-selves of self. CDs (sub-CDs) in turn serve as geometric correlates for selves (sub-selves). The quasi-stationary segments of EEG become correlates for sub-selves/mental images. Operational module corresponds to a self/CD having sub-selves/sub-CDs with synchronous EEG segments. The average duration of mental image would be about .3 seconds. Two sub-sequent quasi-stationary segments separated by RTP would correspond to sub-self and its re-incarnation in the original time direction. Note that a very brief period of geometric time defined by the duration of RTP identifiable as the duration of a unitary time evolution between two sub-sequent state function reductions at the same boundary of CD corresponds to a finite duration of experienced time - the lifetime of the time reversed mental image!

The testable prediction is that the segment corresponding to time-reversed sub-self is located in geometric past and runs in opposite direction of geometric time. This EEG segment should be assignable to motor response accompanying sensory mental image. This is a highly nontrivial prediction testing the new view about time.

3. One can check whether these EEG segments appear as pairs with first member assignable to sensory mental image and second one to motor mental image. Time reversal implies that second law is obeyed in "wrong" time direction for EEG segment assignable to the motor output and this can be tested. Already Fantappie [J82] discovered that both directions of (geometric) time appear in living matter and introduced the notion of syntropy as time reversal of entropy. Spontaneous molecular self-assembly is a basic example of a syntropic process and identifiable as a decay process in reverse direction of geometric time. Phase conjugation is known to occur for phase conjugate laser light and sound. Does a process analogous to self-assembly occur for segments of EEG associated with motor actions: is the motor part of EEG time reversed? To answer this question one needs phase information about EEG besides power spectrum. In principle this information is contained in EEG.

Do conscious entities with different time arrows interact?

Zero Energy Ontology (ZEO) predicts conscious entities with both arrows of geometric time. I find that forcing myself to think and write about this is difficult. The fear is that the whole nice scenario falls down by predicting something totally absurd. The questions that I try to avoid are following. What could these ghostly time-reversed entities be? Do they interact with those with standard time orientation? How could they do so?

Let us first briefly recall what ZEO based theory of consciousness says.

- 1. In ZEO self corresponds to a generalized Zeno effect that is sequence of state function reductions leaving the passive boundary of CD unaffected as also the members of state pairs associated with 3-surfaces at it. At active boundary the members of state pairs change and the active boundary drifts reduction by reduction farther away from passive boundary. The temporal distance between the tips of CD increases gradually and corresponds to the experience about flow of time.
- 2. Negentropy Maximization Principle (NMP) [K80] forces eventually self to die by making the first reduction to the passive boundary of its causal diamond (CD), which now becomes the active boundary: a new time reversed self is born. This option is forced because it produces more negentropy. For this self the arrow of geometric time would be opposite since now the formerly passive boundary would be active and shift in opposite direction of time: in this manner CD would steadily increase in size.

Also the time-reversed self would eventually die and make the first reduction to the opposite - the original - boundary of CD. The position of the boundary of active boundary in first reduction would be shifted to the geometric future from the original position. The first and - as will be found - probably wrong guess for the size of shift towards geometric future from the position at the moment of previous death would be as the average increase of the temporal distance between tips of CD during Zeno period. This increment could be rather small as compared to the size of CD itself.

This picture raises questions.

1. Do we make this kind jump to time-reverse life at some level of our personal self hierarchy as we fall sleep? If wake-up period corresponds to re-incarnation in the original time direction, time increment of CD from its previous value would be the duration of sleeping period as seen by a larger conscious system. This is much longer than the subjective chronon for sensory mental images about .1 seconds.

Remark: Note that EEG splits to pieces of duration about 300 ms and it might be possible to identify in EEG periods, which correspond to mental images and their time reversals. These periods could differ by a phase conjugation although the power spectrum would have the same typical behavior (sound wave and its phase conjugate have same power spectrum but we can distinguish sound and its time-reversal from each other).

Could the first big reduction correspond to a time increment, which is of the same order of magnitude as the total time duration of life-cycle of the time-reversed self? The size of 3-surfaces at the boundary of time-reversed CD has increased by about life-time. Could the first reduction to the opposite boundary increase the size of the 3-surface at this boundary by the same amount? If so, the re-incarnations for human life cycles would take roughly life-time after the death.

Could one identify negative energy time reversed signal as time-reversed self at some level of hierarchy? If so then the selves associated with CDs could gradually increase their energy by dying and re-incarnating repeatedly since the opposite boundary would increase also the magnitude of the negative energy at the opposite boundary. This is in principle possible since conservation laws hold true by the very definition of zero energy states as well as for classical time evolutions appearing in their quantum superposition. The average energy for a given member of pair defining zero energy state would increase gradually. The size of the CD associated with re-incarnating self could become arbitrary large and gain an arbitrary high total energy: the wildest speculation is that cosmologies correspond to very large selves [L50].

- 2. Could selves/systems living in opposite directions of time have direct interactions? If the vision that motor actions are realized as negative energy signals travelling to brain of the geometric past and induce neural activity fraction of second earlier than the conscious decision was made (Libet's finding), this could be the case. Motor action could correspond to a death of sensory self, reincarnation as time-reversed motor-self, and a re-incarnation as sensory self in time scale of .1 seconds. Sensory-motor cycle would correspond to a sequence of re-incarnations as time reversed sub-self.
- 3. How the time reversed selves could reveal themselves? If their presence can be indeed detected, a key signature would be the opposite direction of the thermodynamical arrow of time for them. Heat would be apparently transferred in wrong direction: from cold to hot. This kind of apparent breakings of second law have been observed: phase conjugate laser waves and acoustic signals represent examples of this. Fantappie suggested that they occur routinely in living matter and introduce the notion of syntropy as time reverse counterpart of entropy [J82]. The strange cooling of the air at magnetic walls associated with the rotating magnetic systems [L59] provides second example.
- 4. Good music is claimed to send cold shivers in spine and sensations of cold are assigned also with the perception of ghosts. Could the claims about encounters of ghosts be due to a perception of time reversed selves? I remember that in my personal great experience for three decades ago the entire body went into a state analogous to that created by a good music. Did I interact with a time reversed conscious entity? My experience indeed was that I was in contact with what I called Great Mind. This is of course just a subjective experience and the skeptic scientist knows that I was in a psychotic state since it is completely obvious from my scientific work even without reading it that I am a madman.

4.10 Appendix: TGD and quantum biology

The ontology behind the applications involves the notion of many-sheeted space-time, ZEO, hierarchy of Planck constants identified in terms of dark matter, and p-adic physics as physics of cognition. Also magnetic body (MB) carrying dark matter and energy having non-standard value of Planck constant $h_{eff} = n \times h$ identified as intentional agent represents new ontology. The additional assumption $h_{eff} = h_{qr}$ identifying h_{eff} with gravitational Planck constant is rather powerful. Also p-adic length scale hypothesis is also central in applications. NMP is the basic variational principle of consciousness and means that living systems must do their best to build negentropy resources to avoid the first reduction to the opposite boundary of personal CD. This strong suggests that metabolic energy necessary for survival is needed to transfer NE from the nutrients and the ADP-ATP cycle is essentially transfer of NE in molecular scale.

4.10.1 The notion of magnetic body (MB)

MB is assumed to be carrier of dark matter.

1. The flux tubes of MB can suffer h_{eff} changing phase transitions inducing the change of the length of flux tube. This leads to a view about living matter as a network of bio-molecules connected by magnetic flux tubes. The ability of biomolecules to find each other in the dense molecular soup would rely on the reduction of h_{eff} bringing molecules near each other. The reconnections of flux tubes possible if the field strengths are same and therefore also cyclotron frequencies are identical are also expected to central element in bio-communications since they change the topology of the network and make possible analogs of relays.

The receptors to which information molecules attach could be seen as plugs to which magnetic flux tubes having information molecule at its end attach and give rise to a fusion of two flux tubes to a longer flux tube connection. For instance, nerve pulse transmission would be more like building quantum connections than communication.

2. Flux tubes with large h_{eff} make possible high T_c superconductivity [K100, K101]. Superconducting structures would be pairs of flux tubes carrying magnetic fluxes which have same or opposite directions. Cooper pairs would have members at separate flux tubes.

MB as intentional agent

Magnetic field associated with a given system decomposes to flux tubes and sheets to that system has MB (MB). The physics of MBs could be a new chapter in physics and MB could define the basic space-time correlate for non-locality.

1. Flux tubes of MB would serve as correlates for quantum entanglement, which in TGD framework can be negentropic and for this reason rather stable under state function reductions. In GRT context the idea about wormholes as correlates of entanglement between blackholes is highly analogous. The problem with wormholes is that they are highly unstable. Magnetic flux tubes carrying monopole flux are stable since flux conservation prevents their pinching. The pairs of flux tubes wit opposite fluxes can however split to two U-shaped flux tubes by reconnection. It is important to notice that magnetic flux tubes are necessarily closed and can be regarded as flux running along different space-time sheets in opposite direction and from sheet to another through the wormhole contacts at ends.

One can of course ask whether the braiding of flux tubes could be the correlate for entanglement. To my opinion entanglement without braiding is possible.

- 2. MB and dark matter at it would serve as intentional agent in biological systems [?]. The organism-environment duality would be replaced by the trinity MB-organism-environment. For instance, EEG and its strong correlation with brain state and consciousness could be understood in terms of communication of sensory data from cell membranes to MB and control and coordination signals from MB to biological body [K48]. Signals would consist of dark photons with with energies $E = h_{eff}f = n \times hf$ in bio-photon energy range and thus above thermal energies. For instance, the recently observed synchrony between hemispheres in absence of corpus callosum [J57] could be understood in terms of MB serving as "boss".
- 3. The formation of flux tube reconnections would serve as a correlate for directed attention attention could be directed to objects of external world or to their representations in brain. The reconnection would take place for U-shaped flux tubes serving as kind of magnetic tentacles and lead to a formation of pairs of flux tubes connecting the two systems. If flux tubes carry monopole flux as one has reasons to expect, the flux tubes would be actually

closed two-sheeted structures (also elementary particles would be this kind of structures) and flux tube pair would be pair of these. The flux tubes of MBs would serve as analogs of wave guides along with precisely targeted communications of dark photon signals ("massless extremals" (MEs)) would be possible. Also supra currents would be possible and the TGD based model of high T_c superconductivity relies on the same mechanism [K100]. These communications would be essential in living matter.

4. The formation of reconnections and phases transitions $n \to m$ changing $h_{eff} = n \times h$ would be a basic mechanism behind biocohemistry. U-shaped flux tubes would act like tentacles emerging from the system and reconnection of the tentacles would build a connection between two systems. The reduction of Planck constant would shorten the connecting flux tubes and could force the systems in the vicinity of each other after which bio-catalysis could take place. Braiding and its 2-braid variant for string world sheets and partonic 2-surfaces in 4-D space-time instead of strings in 3-D space would make possible realization of quantum computer program like structures.

MB is 4-dimensional

MB as preferred extremal represents in terms of space-time topology and geometry 4-D selforganization patterns, behaviors, functions, and skills. What is new that self-organization occurs for 4-D patterns rather than 3-D ones. The entire process is replaced with a new one. Sequence of state function reductions leads from a 4-D self-organization pattern to an asymptotic 4-D selforganization pattern [K99].

Morphogenesis provides examples of this kind of phenomena [I104, I105, I129]. The first key idea is that DNA and cell replication is induced by the replication of MBs serving as information carriers (see http://tinyurl.com/ydg6okkk) [K99]. The second key idea is that in ZEO MB is 4-dimensional and represents behavioral patterns rather than only 3-dimensional patterns.

According to Michael Levin, concerning morphogenesis and morphostasis the basic challenge is to understand how the shape of the organism is generated and how it is preserved. The standard local approach based on belief on genetic determinism does not allow one to answer these questions satisfactorily.

- 1. The first approach to this problem relies on a self-organization paradigm in which the local dynamics of cells leads to large scale structures as self-organization patterns. In TGD framework 3-D self-organization is replaced with 4-D self-organization (the failure of strict determinism of the classical dynamics is essential motivating zero energy ontology (ZEO)). One can speak about 4-D healing: expressing it in somewhat sloppy manner, the space-time surface serving as a classical correlate for the patient is as a whole replaced with the healed one: after the 4-D healing process the organism was never ill in geometrical sense! Note that in quantal formulation one must speak of quantum superposition of space-time surfaces.
- 2. Second approach could be seen as computational. The basic idea is that the process is guided by a template of the target state and morphogenesis and healing are computational processes. What Levin calls morphogenetic fields would define this template. It is known that organisms display a kind of coordinate grid providing positional information that allows cells to "decide" about the profile of genetic expression (for references see [I105]). In TGD framework MB forming coordinate grid formed from flux tubes is a natural candidate for this structure. They would also realize topological quantum computation (TQC) with basic computational operations realized at the nodes of flux tubes to which it is natural to associate some biological sub-structures.

The assumption about final goal defining a template can be argued to be too strong: much weaker principle defining a local direction of dynamics and leading automatically to the final state as something analogous to free energy minimum in thermodynamics might be enough. Unfortunately, second law is the only principle that standard physics can offer. Negentropy Maximization Principle (NMP) provides the desired principle in TGD framework. Also the approach of WCW spinor field to the maximum of vacuum functional (or equivalently that of Kähler function) gives a goal for the dynamics after the perturbation of the organism causing "trauma". If Kähler function is classical space-time correlate for entanglement negentropy, these two views are equivalent.

TGD thus suggests an approach, which could be seen as a hybrid of approaches based on selforganization and computationalism. The MB becomes the key notion and codes also for learned behaviors as TQC programs coded by the braiding of flux tubes. The replication of the MB means also the replication of the programs behind behavioral patterns (often somewhat misleadingly regarded as synonymous with long term memories): both structure and function are replicated. This hypothesis survives the killer tests provided by the strange findings about planaria cut into two and developing new head or tail while retaining its learned behaviors: the findings indicate that behavioral programs are preserved although planaria develops a new brain.

$h_{gr} = h_{eff}$ hypothesis

Nottale [E1] introduced originally the notion of gravitational Planck constant $\hbar_{gr} = GMm/v_0$, where M is large mass such as that of Earth or Sun and m the mass of quantum coherent object and v_0 is a parameter with dimensions of velocity [E1]. Nottale did not propose macroscopic quantum coherence in astrophysical scales but in TGD framework this is a natural option [K117, K93].

The obvious question is whether the gravitational Planck constant deduced from the Nottale's considerations and the effective Planck constant $h_{eff} = n \times h$ deduced from ELF effects on vertebrate brain and explained in terms of non-determinism of Kähler action could be identical. At first this seems to be non-sensical idea since $\hbar_{gr} = GMm/v_0$ has a gigantic value. The hypothesis $h_{eff} = h_{gr}$ leads to much stronger predictions [K95, ?] than either hypothesis alone. One can also introduce analogs of h_{gr} for other interactions: the idea is that when the coupling strength between two charges becomes so large that perturbation theory does not exist, a phase transition increasing the Planck constant happens and guarantees the convergence.

The essential point is that h_{eff} and h_{gr} would characterized body parts of MB: this allows to understand the dependent on masses of two particles. The flux tubes with a given value of h_{eff} would carry only particles of particular mass m so that the random soup of biomolecules would become a highly ordered structure analogous to library in which each book type is its own shelf. Furthermore, the cyclotron energies $E_c \propto h_{eff}/m$ would be same irrespective of particle mass malthough cyclotron frequencies are different.

The proposed identification of the energy range of dark photon cyclotron energies in living matter is as visible and UV range assigned to bio-photons which would therefore result in the transformation of dark photons to ordinary photons. Further important point, is that the energy spectrum would be in the range of molecular excitation energies (visible and UV range) so that dark photons transformed to ordinary ones would allow MBs to control biochemistry.

By Equivalence Principle one can describe gravitational interaction by reducing it to elementary particle level. For instance, gravitational Compton lengths do not depend at all on the masses of particles. Also the radii of the planetary orbits are independent of the mass of particle mass in accordance with Equivalence Principle. For elementary particles the values of h_{gr} are in the same range as in quantum biological applications. Typically 10 Hz ELF radiation should correspond to energy $E = h_{eff} f$ of UV photon if one assumes that dark ELF photons have energies of biophotons and transform to them. The order of magnitude for n would be therefore $n \simeq 10^{14}$.

The experiments of M. Tajmar *et al* [E2, E5] discussed in [K122] provide a support for this picture. The value of gravimagnetic field needed to explain the findings is 28 orders of magnitude higher than theoretical value if one extrapolates the model of Meissner effect to gravimagnetic context. The amazing finding is that if one replaces Planck constant in the formula of gravimagnetic field with h_{gr} associated with Earth-Cooper pair system and assumes that the velocity parameter v_0 appearing in it corresponds to the Earth's rotation velocity around its axis, one obtains correct order of magnitude for the effect requiring $r \simeq 3.6 \times 10^{14}$.

The most important implications are in quantum biology and Penrose's vision about importance of quantum gravitation in biology might be correct.

1. This result allows by Equivalence Principle the identification $h_{gr} = h_{eff}$ at elementary particle level at least so that the two views about hierarchy of Planck constants would be equivalent. If the identification holds true for larger units it requires that space-time sheet identifiable as quantum correlates for physical systems are macroscopically quantum coherent and gravitation causes this. If the values of Planck constant are really additive, the number of parallel space-time sheets corresponding to non-determinism evolution for the flux tube connecting systems with masses M and m is proportional to the masses M and m using Planck mass as unit. Information theoretic interpretation is suggestive since hierarchy of Planck constants is assumed to relate to negentropic entanglement very closely in turn providing physical correlate for the notions of rule and concept.

- 2. That gravity would be fundamental for macroscopic quantum coherence would not be surprising since by EP all particles experience same acceleration in constant gravitational field, which therefore has tendency to create coherence unlike other basic interactions. This in principle allows to consider hierarchy in which the integers $h_{gr,i}$ are additive but give rise to the same universal dark Compton length.
- 3. An interesting question is how large systems can behave as coherent units with $\hbar_{gr} = GMm/v_0$. In living matter one might consider the possibility that entire organism might be this kind of system. Interestingly, for larger masses the gravitational quantum coherence would be easier. For particle with mass $m h_{gr}/h > 1$ requires larger mass to satisfy $M > M_P^2/m_e$. The first guess that life has evolved from long to shorter scales and reached elementary particle last. Planck mass is the critical mass corresponds to the mass of water blog with volume of size scale of 10^{-4} m (big neuron) is the limit.

The general proposal discussed above is testable. In particular, a detailed study of molecular energies with those associated with resonances of EEG could be highly rewarding and reveal the speculated spectroscopy of consciousness.

EEG as communications between MB and BB

Models of EEG and nerve pulse are basic applications of the notion of MB in neuroscience. The basis idea is that EEG and its fractal counterparts are communications to the various layers of MB having onion-like structure with cyclotron frequency correlating with the size of the layer. Josephson junctions about which basic example is cell membrane would communicate sensory information to MB as dark photons.

The general model for EEG follows neatly from this picture combined with the general model of high T_c superconductivity [K100, K101]. A fractal hierarchy of EEGs and its generalizations identified in terms of generalized Josephson radiation is predicted with levels labeled by p-adic length scales and the value of \hbar at various levels of dark matter hierarchy [K48]. At macrolevel one can approximate neuronal and axonal (and also cell-) membrane as Josephson junction formed by the two lipid layers of the membrane. At microscopic level ionic pumps and channels defined by Josephson junctions involving magnetic flux tubes connecting interior and exterior of the cell.

"Generalized" means that Josephson frequency as energy difference $E = ZeV/h_{eff}$ of Cooper pair for membrane potential is replaced with the sum of difference of cyclotron energies and E. This implies that the variations of membrane potential by oscillations and nerve pulses induced frequency modulation of the frequency of dark photons sent to the MB. This defines a coding of the information carried by nerve pulses do dark photons. Whale's song represents a good analogy for the coding. Besides EEG one would have its counterparts for various organs, organelles and even cell.

Experimental evidence for MB

The team led by Michael Tyszka, associate director of Caltech Brain Imaging Center, has however discovered that the resting state network seems to work normally in people born without corpus callosum [J57] (see http://tinyurl.com/3gjhtgb)! As if brain hemispheres were communicating by some other means than neural signalling! This finding challenges not only the views about the origin of brain synchrony as being created by neural circuits but also the models of autism and schizophrenia explaining them in terms of impaired communications between hemispheres.

The MB of entire brain controls it and could naturally do this via the intermediate control of brain hemispheres forcing them to operate in the same rhythm. Brain synchrony and resting network would not be produced by resonant neuro-circuits as usually believed but by the spatiotemporal coherence of the EEG radiation from the MB of entire brain forcing brain hemisphere MBs to oscillate in the same rhythm and in turning synchronizing the brain hemispheres [K98]. This would be like forcing soldiers to march in the same pace and brain hemispheres could cooperate without any neural communication between hemispheres. The communication between
hemispheres would be needed for more refined collaboration involving "discussion" between hemispheres: hemispheres of a person without corpus callosum would be like soldiers obeying blindly the orders. This might be also an essential element of autism and schizophrenia.

4.10.2 MB and biology

MB could play a key role in biology as intentional agent using biological body as motor instrument. MB could even serve as a template for biomolecules and even that fundamental bio-chemical processes are induced by those for MB. Dark cyclotron photons transformed to ordinary photons would be the fundamental control tool of MB. Also reconnection of flux tubes, change of length of flux tubes induced by the change of the value of $h_{eff} = h_{gr}$, superconductivity associated with a pair of flux tubes could be fundamental control mechanisms.

MB, biophotons, and biochemistry

The model for quantum biology relying on the notions of MB and dark matter as hierarchy of phases with $h_{eff} = nh$, and biophotons [L28, K20] identified as decay produces of dark photons. The assumption $h_{gr} \propto m$ becomes highly predictable since cyclotron frequencies would be independent of the mass of the ion.

- 1. If dark photons with cyclotron frequencies decay to biophotons, one can conclude that biophoton spectrum reflects the spectrum of endogenous magnetic field strengths. In the model of EEG [K48] it has been indeed assumed that this kind spectrum is there: the inspiration came from music metaphors suggesting that musical scales are realized in terms of values of magnetic field strength. The new quantum physics associated with gravitation would also become key part of quantum biophysics in TGD Universe.
- 2. For the proposed value of h_{gr} 1 Hz cyclotron frequency associated to DNA sequences would correspond to ordinary photon frequency $f = 3.6 \times 10^{14}$ Hz and energy 1.2 eV just at the lower limit of visible frequencies. For 10 Hz alpha band the energy would be 12 eV in UV. This plus the fact that molecular energies are in eV range suggests very simple realization of biochemical control by MB. Each ion has its own cyclotron frequency but same energy for the corresponding biophoton.
- 3. Biophoton with a given energy would activate transitions in specific bio-molecules or atoms: ionization energies for atoms except hydrogen have lower bound about 5 eV (http://tinyurl.com/233vcad). The energies of molecular bonds are in the range 2-10 eV (http://tinyurl.com/yccmm7mm). If one replaces v₀ with 2v₀ in the estimate, DNA corresponds to .62 eV photon with energy of order metabolic energy currency and alpha band corresponds to 6 eV energy in the molecular region and also in the region of ionization energies.

Each ion at its specific magnetic flux tubes with characteristic palette of magnetic field strengths would resonantly excite some set of biomolecules. This conforms with the earlier vision about dark photon frequencies as passwords.

It could be also that biologically important ions take care of their ionization self. This would be achieved if the magnetic field strength associated with their flux tubes is such that dark cyclotron energy equals to ionization energy. EEG bands labelled by magnetic field strengths could reflect ionization energies for these ions.

It must be made clear that TGD has had an interpretational problem related to the identification of biophotons as decay product of dark protons [?, K95]. The resolution of this problem leads to conclusion that both Earth's and galactic MBs control living matter with EEG related by scaling. This would be rather dramatic realization of non-locality.

The problem is following. If one wants bio-photon spectrum to be in visible-UV range assuming that bio-photons correspond to cyclotron photons, one must reduce the value of $r = h_{gr}B_{end}/mv_0$ for Earth particle system by a factor of order $k = 2 \times 10^{-4}$. r does not depend on the mass of the charged particle. One can replace B_{end} with some other magnetic field having value which is considerably smaller. One can also increase the value of v_0 . 1. For h_{gr} determined by Earth's mass and $v_0 = v_{rot}$, where $v_{rot} \simeq 1.55 \times 10^{-6}c$ is the rotation velocity of Earth around its axis and for $B_{end} \rightarrow B_{gal} = 1$ nT, where B_{gal} is typical strength of galactic magnetic field, the energy of dark cyclotron energy is 45 eV (UV extends to 124 eV). This is roughly by a factor 50 higher than the lower bound for the range of bio-photon energies. One possibility is that B_{gal} defines the upper limit of the dark photon energies and has variation range of at least 7 octaves with lower limit roughly 1/50 nT.

One can also consider the possibility B_{gal} defines lower bound for the magnetic field strengths involved and one has $v_0 > v_{rot}$. For sun the rotation velocity at Equator is $v_{rot} = 2 \times 10^{-5}$ m/s and v_0 is $v_0 \simeq 5.8 \times 10^{-4}c$. One has $v_0/v_{rot} \simeq 29.0$. If same is true in case of Earth, the value of the energy comes down from 25 eV to 1.6 eV which corresponds to visible wave length.

The assignment of B_{gal} to gravitational flux tubes is very natural. Now however the frequencies of dark variants of bio-photons would not be in EEG range: 10 Hz frequency would correspond to $5 \times 10-4$ Hz with period of 42 min. The time scale of 42 min is however very natural concerning consciousness and could be involved with longer bio-rhythms. Scaled EEG spectrum with alpha band around 46 min naturally assignable to diurnal sub-rhythms could be a testable prediction. Natural time would be sidereal (galactic) time with slightly different length of day and this allows a clear test. Recall the mysterious looking finding of Spottiswoode that precognition seems to be enhanced at certain time of sidereal day [J78]. Cyclotron frequency 1 Hz would correspond to 7 hours. One can ask whether 12 hours (25) is the natural counterpart for the cyclotron frequency 1 Hz assignable to DNA. This would correspond to lower bound $B_{gal} \rightarrow 7B_{gal}/12 \simeq .58$ nT or to $v_0 \rightarrow 1.7v_0$.

2. The idea has been that it is dark EEG photons, which correspond to bio-photons. Could one assign bio-photons also to dark EEG so that magnetic fields of Earth and galaxy would correspond to two different control levels? If $B_{end} = .2$ Gauss is assumed to determine the scale of the magnetic field associated with the flux tubes carrying gravitational flux tubes, one must reduce h_{gr} . The reduction could be due to $M \to M_D = kM$ and due to the change of v_0 . k could characterize the dark matter portion of Earth but this assumption is not necessary.

This would require $k = M_{dark,E}/M_E \simeq 5 \times 10^{-5}$ if one does not change the value of v_0 . This value of k equals to the ratio of B_{gal}/B_{end} and would be 1/4:th of $k = 2 \times 10^{-4}$. One might argue that it is indeed dark matter to which the gravitational flux tubes with large value of Planck constant connect biomatter.

3. Suppose that one does not give up the idea that also Earth mass gives rise to h_{gr} and scaled analog of EEG. Then M_D must correspond to some mass distinguishable from and thus outside Earth. The simplest hypothesis is that a spherical layer around Earth is in question. TGD based model for spherical objects indeed predict layered structures [K137]. 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 equal to 60.3 Earth radii [K117]. 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.

One can imagine that dark particles reside at the flux tubes connecting diametrically opposite points of the spherical layer. Particles would experience the sum of gravitational forces summing up to zero in the center of Earth. Although the layer would be almost invisible (or completely invisible by argument utilizing the analogy with conducting shell) gravitationally in its interior, $h_{gr} = M_D m/v_0$ would make itself visible in the dynamics of dark particles! This layer could represent magnetic Mother Gaia and EEG would take care of communications to this layer.

The rotation velocity $v_{rot,M} \simeq 2.1 \times v_{rot,E}$ of Moon around its axis is the first guess for the parameter v_0 identifiable perhaps as rotation velocity of the spherical layer. A better guess is that the ratio $r = v_0/v_{rot,M}$ is the same as for Sun and as assumed above for Earth. This would give for the ratio of cyclotron frequency scales $r = (B_{end}/B_{gal}) \times 2.1$. 66.7 min, which

corresponds to $B_{gal} = .63$ nT, would correspond to .1 s. For this choice 1 Hz DNA cyclotron frequency would correspond 11.7 h rather near to 12 h. This encourages the hypothesis that 72 min is the counterpart of .1 s cyclotron time. The cyclotron time of DNA (very weakly dependent on the length of DNA double strand) in B_{gal} (or its minimum value) would be 12 h.

Magnetic body of Earth controlling bio-dynamics would be a dramatic manifestation of non-locality to say nothing about the control performed by galactic magnetic body. M_D would be associated with the magnetic Mother Gaia making life possible at Earth together with magnetic Mother Galactica. Both MBs would be in continual contact with biomolecules like ATP and the molecules for which ATP attaches or provides the phospate. Metabolic energy would be used to this process. These MBs would be Goddesses directing its attention to tiny bio-molecules. If this picture is correct, the ideas about consciousness independent on material substrate and assignable to a running computer program can be safely forgotten.

Model for the flux tube connections between biomolecules

A more concrete TGD based model for the flux tubes connections between molecules relies on the general ideas of TGD inspired quantum biology [K78].

- 1. Biomolecules containing aromatic rings are known to play a fundamental role. For instance, most neurotransmitters and psychoactive drugs involve aromatic rings). All DNA nucleotides contain them and there are 4 proteins, which also have them. Trp and phe are of special importance and form a pair structurally analogous to a base pair in DNA strand. The rings are assumed to carry the analog of supra current and be in or at least be able to make transition to a state with large $h_{eff} = n \times h$. The delocalization of electron pairs in aromatic ring could be a signature of $h_{eff}/h > 1$.
- 2. Trp-phe pairing [K78] would be responsible for information molecule-receptor pairing. Information molecule and receptor would be at the ends of flux tubes serving as communication lines, and the attachment of info molecule to receptor would fuse the two flux tubes to longer one. After that communication would become possible as dark photon signals and dark supra currents. Formation of info molecule-receptor complex would be like clicking icon generating a connection between computers in net. Info molecules would generate the communication channels they would not yet be the signals. This distinguishes TGD view from standard neuroscience.
- 3. All quantum critical phenomena involve generation of large h_{eff} phases and changes of h_{eff} in the sense that their values are different at different ends of space-time surface at boundaries of CD. Folding emerges or disappears at QC possible in certain temperature range of width about 40 K and depending on pH. The flux tubes associated with phe and trp containing aromatic rings carrying "supra current" would become dark (either $h \rightarrow h_{eff}$ or $h_{eff} > h$ increases) and thus much longer and reconnect temporarily and force phe and trp in a close contact after the reverse transition inducing shortening. This is a general mechanism making biomolecules able to find each other in what looks like molecular soup in the eyes of standard biochemist. The contacts between amino-acids phe and trp formed in this manner would be structurally identical with the hydrogen bonding between members of DNA base pairs and they would fix the final folding pattern to high degree.

Pollack's mechanism

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 [L36, I137, I115] (see http: //tinyurl.com/oyhstc2). 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 MB assignable to the exclusion zone and outside it [L36] [K78].

This leads to a model for prebiotic cell as exclusion zone. Dark protons are proposed to form dark nuclear strings 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 [L3, K62]. 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.

Pollack's exclusion zones (EZs) might for instance explain why DNA is negatively charged. EZs or their generalization could play fundamental role in metabolism with protons running through mitochondrial membrane being dark as also other biologically important ions involved. EZs could be important even in electrolysis and allow to explain what happens in cold fusion. These hypothesis could be tested.

Why metabolism is needed?

The simplest and at the same time most difficult question that innocent student can make about biology class is simple: "Why we must eat?". Or using more physics oriented language: "Why we must get metabolic energy?". The answer of the teacher might be that we do not eat to get energy but to get order. The stuff that we eat contains ordered energy: we eat order. But order in standard physics is lack of entropy, lack of disorder. Student could get nosy and argue that excretion produces the same outcome as eating but is not enough to survive.

We could go to a deeper level and ask why metabolic energy is needed in biochemistry. Suppose we do this in TGD Universe with dark matter identified as phases characterized by $h_{eff}/h = n$. At deeper level metabolic energy should closely relate to negentropic entanglement (NE) and thus information. Identification of these two is however not possible. I have considered several answers to the question why metabolic energy is needed. Here two answers will be discussed.

- 1. Conscious information could be the basic currency and the transfer of metabolic energy and metabolites would make possible transfer of NE. Is the transfer of metabolic energy essentially transfer of NE? Could the transfer of NE require metabolic energy? NE transfer could be transfer of systems consisting of negentropically entangled parts or it could be transfer of NE with larger system, even Earth. NMP would force the systems to fight for NE and this would lead to the fight for metabolic resources. The transfer of entanglement is the basic mechanism in quantum computation and would mean in biology stealing of NE, the fundamental crime! The ideas related to metabolism in TGD Universe are discussed in detail in [K68].
- 2. Could metabolic energy needed to generate NE from scratch? For this option the molecules providing the metabolic energy contain dark atoms. Of course, the nutrients could already contain the negentropic entanglement and photosynthesis could serve as fundamental generator of NE. The following naïve model for dark atoms obtained by replacing h with h_{eff} supports this view.
 - (a) The binding energy spectrum of dark hydrogen atom is scaled by $1/n^2$, $n = h_{eff}/h$ (do not confuse this *n* with the integer *n* labelling the states of hydrogen atom!) so that generation of dark hydrogen atoms would require energy. Dark atoms have smaller binding energies and their creation by a phase transition increasing the value of *n* demands a feed of energy metabolic energy! If the metabolic energy feed stops, *n* is gradually reduced. System gets tired, loses consciousness, and eventually dies. Also in case of cyclotron energies the positive cyclotron energy is proportional to h_{eff} so that metabolic energy is needed to generate larger h_{eff} and prerequisites for negentropy.
 - (b) The analogy of weak form of NMP following from mere adelic physics makes it analogous to second law. Could one consider the purely formal generalization of dE = TdS - ...to dE = -TdN - ..., where E refers to metabolic energy and N refers to entanglement negentropy? No: the situation is different. The system is not closed system; N is not the negative of thermodynamical entropy S; and E is the metabolic energy feeded to the system, not the system's internal energy. dE = TdN - ... might however make sense for a system to which metabolic energy is feeded.

The identification of N is still open: N could be identified either as $N = \sum_p N_p - S$, where one has sum of p-adic entanglement negentropies and real entanglement entropy S or as $N = \sum_p N_p$. For the first option one would have N = 0 for rational entanglement and $N \ge 0$ for extensions of rationals. Could rational entanglement be interpreted as that associated with dead matter in this case?

- (c) Bio-catalysis and ATP \leftrightarrow ADP process need not require metabolic energy. A transfer of negentropy from nutrients to ATP to acceptor molecule would be in question. Metabolic energy would be needed to reload ADP with negentropy to give ATP by using ATP synthase as a mitochondrial power plant. Metabolites could be carriers of dark atoms of this kind possibly carrying also NE. They could also carry NE associated with the dark cyclotron states as suggested earlier and in this case the value of $h_{eff} = h_{gr}$ would be much larger than in the case of dark atoms.
- (d) What is remarkable that the scale of atomic binding energies decreases with n only in dimension D = 3. In other dimensions it increases and in D = 4 one cannot even speak of bound states! This can be easily found by a study of Schrödinger equation for the analog of hydrogen atom in various dimensions [L52]. Life based on atomic metabolism seems to make sense only in spatial dimension D = 3. Note however that there are also other quantum states than atomic states with different dependence of energy on h_{eff} .

Identification of NE possibly transferred in metabolism

I have considered several identifications of NE.

- 1. NE could be small scale entanglement say between molecules having dark atoms. The short scale of entanglement does not conform with the large values of h_{gr} . One can however have also $h_{eff}/h = h_{em}/h = Z_1 Z_2 \alpha_{em}$. This would give rise to NE in short scales. The transfer of metabolic energy in ATP \leftrightarrow ADP process could correspond to the transfer of short ranged NE.
- 2. NE could be between nutrient and larger structure say Earth, Sun, or some other large enough structure to give a value of $\hbar_{gr} = GMm/v_0$ guaranteeing that dark cyclotron energies (no dependence on mass m) in the range of bio-photon energies (visible and UV) and guarantee that EEG frequencies correspond to these energies. This option discussed in [K95]. Also long range entanglement could be present and correspond to a higher evolutionary level. A possible candidate for the larger structure could be a spherical layer at the distance of Moon from Earth would give correct value for $h_{eff} = h_{gr}$ [K95].

Nutrients could be carriers of both metabolic energy and of NE - both short and long ranged. Even electrons can provide metabolic energy and in TGD framework therefore also NE for some bacteria (see http://tinyurl.com/o8xqh6g): in this case only short range entanglement would be involved.

3. NE could be also between a larger structure and phosphate molecule added to ADP using metabolic energy. This option would predict that phosphates are in unique role as standard entanglers to mass M. Any source of metabolic energy is in principle possible since metabolic energy is only needed to transfer the flux tube connecting phosphate to mass M to ADP so that ATP is obtained. The flux tube would represent the "high energy phosphate bond". ATP in turn attaches the flux tube to biomolecule, which becomes negentropically entangled. Metabolism would be make the transfer of NE possible. Metabolites would not contain information but it would be assignable to the flux tube between phosphate and mass M. Magnetic Mother Gaia would have very concrete meaning.

What happens in bio-catalysis?

Bio-catalysis is key mechanism of biology and its extreme efficacy remains to be understood. Enzymes are proteins and ribozymes RNA sequences acting as biocatalysts.

1. Conditions on bio-catalysis What catalysis demands?

- 1. Catalyst and reactants must find each other. How this could happen is very difficult to understand in standard biochemistry in which living matter is seen as soup of biomolecules. I have already already considered the mechanisms making it possible for the reactants to find each other. For instance, in the translation of mRNA to protein tRNA molecules must find their way to mRNA at ribosome. The proposal is that reconnection allowing U-shaped magnetic flux tubes to reconnect to a pair of flux tube connecting mRNA and tRNA molecule and reduction of the value of $h_{eff} = n \times h$ inducing reduction of the length of magnetic flux tube takes care of this step. This applies also to DNA transcription and DNA replication and bio-chemical reactions in general.
- 2. Catalyst must provide energy for the reactants (their number is typically two) to overcome the potential wall making the reaction rate very slow for energies around thermal energy. The TGD based model for the hydrino atom having larger binding energy than hydrogen atom claimed by Randell Mills [D12] suggests a solution [L52]. Some hydrogen atom in catalyst goes from (dark) hydrogen atom state to hydrino state (state with smaller h_{eff}/h and liberates the excess binding energy kicking the either reactant over the potential wall so that reaction can process. After the reaction the catalyst returns to the normal state and absorbs the binding energy.
- 3. In the reaction volume catalyst and reactants must be guided to correct places. The simplest model of catalysis relies on lock-and-key mechanism. The generalized Chladni mechanism forcing the reactants to a two-dimensional closed nodal surface is a natural candidate to consider. There are also additional conditions. For instance, the reactants must have correct orientation. For instance, the reactants must have correct orientation and this could be forced by the interaction with the em field of ME involved with Chladni mechanism.
- 4. One must have also a coherence of chemical reactions meaning that the reaction can occur in a large volume - say in different cell interiors - simultaneously. Here MB would induce the coherence by using MEs. Chladni mechanism might explain this if there is there is interference of forces caused by periodic standing waves themselves represented as pairs of MEs.

2. Phase transition reducing the value of $h_{eff}/h = n$ as a basic step in bio-catalysis

Hydrogen atom allows also large $h_{eff}/h = n$ variants with n > 6 with the scale of energy spectrum behaving as $(6/n)^2$ if the n = 4 holds true for visible matter. The reduction of n as the flux tube contracts would reduce n and liberate binding energy, which could be used to promote the catalysis.

The notion of high energy phosphate bond is somewhat mysterious concept and manifests as the ability provide energy in ATP to ADP transition. There are claims that there is no such bond. I have spent considerable amount of time to ponder this problem. Could phosphate contain (dark) hydrogen atom able to go to the a state with a smaller value of h_{eff}/h_i and liberate the excess binding energy? Could the phosphorylation of acceptor molecule transfer this dark atom associated with the phosphate of ATP to the acceptor molecule? Could the mysterious high energy phosphate bond correspond to the dark atom state. Metabolic energy would be needed to transform ADP to ATP and would generate dark atom.

Could solar light kick atoms into dark states and in this manner store metabolic energy? Could nutrients carry these dark atoms? Could this energy be liberated as the dark atoms return to ordinary states and be used to drive protons against potential gradient through ATP synthase analogous to a turbine of a power plant transforming ADP to ATP and reproducing the dark atom and thus the "high energy phosphate bond" in ATP? Can one see metabolism as transfer of dark atoms? Could possible negentropic entanglement disappear and emerge again after $ADP \rightarrow ATP$.

Here it is essential that the energies of the hydrogen atom depend on $\hbar_{eff} = n \times h$ in as \hbar_{eff}^m , m = -2 < 0. Hydrogen atoms in dimension D have Coulomb potential behaving as $1/r^{D-2}$ from Gauss law and the Schrödinger equation predicts for $D \neq 4$ that the energies satisfy $E_n \propto (h_{eff}/h)^m$, m = 2+4/(D-4). For D = 4 the formula breaks since in this case the dependence on \hbar is not given by power law. m is negative only for D = 3 and one has m = -2. There D = 3 would be unique dimension in allowing the hydrino-like states making possible bio-catalysis and life in the proposed scenario.

It is also essential that the flux tubes are radial flux tubes in the Coulomb field of charged particle. This makes sense in many-sheeted space-time: electrons would be associated with a pair formed by flux tube and 3-D atom so that only part of electric flux would interact with the electron touching both space-time sheets. This would give the analog of Schrödinger equation in Coulomb potential restricted to the interior of the flux tube. The dimensional analysis for the 1-D Schrödinger equation with Coulomb potential would give also in this case $1/n^2$ dependence. Same applies to states localized to 2-D sheets with charged ion in the center. This kind of states bring in mind Rydberg states of ordinary atom with large value of n.

The condition that the dark binding energy is above the thermal energy gives a condition on the value of $h_{eff}/h = n$ as $n \leq 32$. The size scale of the dark largest allowed dark atom would be about 100 nm, 10 times the thickness of the cell membrane.

Chapter 5

Philosophy of Adelic Physics

5.1 Introduction

I have developed during last 39 years a proposal for unifying fundamental interactions which I call "Topological Geometrodynamics" (TGD). During last twenty years TGD has expanded to a theory of consciousness and quantum biology and also p-adic and adelic physics have emerged as one thread in the number theoretical vision about TGD.

Since Quantum TGD and physical arguments have served as basic guidelines in the development of p-adic ideas, the best way to introduce the subject of p-adic physics, is by describing first TGD briefly.

In this article I will consider the p-adic aspects of TGD - the first thread of the number theoretic vision - as I see them at this moment.

- 1. I will describe p-adic mass calculations based on p-adic generalization of thermodynamics and super-conformal invariance [K74, K36] with number theoretical existence constrains leading to highly non-trivial and successful physical predictions. Here the notion of canonical identification mapping p-adic mass squared to real mass squared emerges and is expected to be key player of adelic physics and allow to map various invariants from p-adics to reals and vice versa.
- 2. I will propose the formulation of p-adicization of real physics and adelization meaning the fusion of real physics and various p-adic physics to single coherent whole by a generalization of number concept fusing reals and p-adics to larger structure having algebraic extension of rationals as a kind of intersection.

The existence of p-adic variants of definite integral, Fourier analysis, Hilbert space, and Riemann geometry is far form obvious, and various constraints lead to the idea of NTU and finite measurement resolution realized in terms of number theory. Maybe the only way to overcome the problems relies on the idea that various angles and their hyperbolic analogs are replaced with their exponentials and identified as roots of unity and roots of e existing in finite-dimensional algebraic extension of p-adic numbers. Only group invariants - typically squares of distances and norms - are mapped by canonical identification from p-adic to real realm and various phases are mapped to themselves as number theoretically universal entities.

Another challenge is the correspondence between real and p-adic physics at various levels: space-time level, embedding space level, and WCW level. Here the enormous symmetries of WCW and those of embedding space are in crucial role. Strong form of holography (SH) allows a correspondence between real and p-adic space-time surfaces induced by algebraic continuation from string world sheets and partonic 2-surface, which can be said to be common to real and p-adic space-time surfaces.

3. In the last section I will describe the role of p-adic physics in TGD inspired theory of consciousness. The key notion is Negentropic entanglement (NE) characterized in terms of number theoretic entanglement negentropy (NEN). Negentropy Maximization Principle (NMP) would force the growth of NE. The interpretation would be in terms of evolution as increase of negentropy resources - Akashic records as one might poetically say. The newest finding is that NMP in statistical sense follows from the mere fact that the dimension of extension of rationals defining adeles increases unavoidably in statistical sense - separate NMP would not be necessary.

In the sequel I will use some shorthand notations for key principles and key notions. Quantum Field Theory (QFT); Relativity Principle (RP); Equivalence Principle (EP); General Coordinate Invariance (GCI); World of Classical Worlds (WCW); Strong Form of GCI (SGCI); Strong Form of Holography (SH); Preferred Extremal (PE); Zero Energy Ontology (ZEO); Quantum Criticality (QC); Hyper-finite Factor of Type II₁ (HFF); Number Theoretical Universality (NTU); Canonical Identification (CI); Negentropy Maximization Principle (NMP); Negentropic entanglement (NE); Number Theoretical Entanglement Negentropy (NEN); are the most often occurring acronyms.

5.2 TGD briefly

This section gives a brief summary of classical and quantum TGD, which to my opinion is necessary for understanding the number theoretic vision.

5.2.1 Space-time as 4-surface

TGD forces a new view about space-time as 4-surface of 8-D imbedding space. This view is extremely simple locally but by its many-sheetedness topologically much more complex than GRT space-time.

Energy problem of GRT as starting point

The physical motivation for TGD was what I have christened the energy problem of General Relativity [K146, K29].

- 1. The notion of energy is ill-defined because the basic symmetries of empty space-time are lost in the presence of gravity. The presence of matter curves empty Minkowski space M^4 so that its isometries realized as transformations leaving the distances between points and thus shapes of 4-D objects invariant are lost. Noether's theorem states that symmetries and conservation laws correspond to each other. Hence conservation laws are lost and conserved quantities are ill-defined. Usually this is not seen a practical problem since gravitation is so weak interaction.
- 2. The proposed way out of the problem is based on the assumption that space-times are imbeddable as 4-surfaces to some 8-dimensional space $H = M^4 \times S$ by replacing the points of 4-D empty Minkowski space with 4-D very small internal space S. The space S is unique from the requirement that the theory has the symmetries of standard model: $S = CP_2$, where CP_2 is complex projective space with 4 real dimensions [K146]. Isometries of space-time are replaced with those of imbedding space. Noether's theorem predicts the classical conserved charges for given general coordinate invariant (GCI) action principle.

Also now the curvature of space-time codes for gravitation. Equivalence Principle (EP) and General Coordinate Invariance (GCI) of GRT augmented with Relativity Principle (RT) of SRT remain the basic principles. Now however the number of solutions to field equations - preferred extremals (PEs) - is dramatically smaller than in Einstein's theory [K14, K21].

1. An unexpected bonus was geometrization classical fields of standard model for $S = CP_2$. Also the space-time counterparts for field quanta emerge naturally but this requires a profound generalization of the notion of space-time: the topological inhomogenities of space-time surface are identified as particles. This means a further huge reduction for dynamical field like variables at the level of single space-time sheet. By general coordinate invariance (GCI) only four imbedding space coordinates appear as variables analogous to classical fields: in a typical GUT their number is hundreds.

- 2. CP_2 also codes for the standard model quantum numbers in its geometry in the sense that electromagnetic charge and weak isospin emerge from CP_2 geometry: the corresponding symmetries are not isometries so that electroweak symmetry breaking is coded already at this level. Color quantum numbers correspond to the isometries of CP_2 defining an unbroken symmetry: this also conforms with empirical facts. The color of TGD however differs from that in standard model in several aspects and LHC has began to exhibit these differences via the unexpected behavior of what was believed to be quark gluon plasma [K82]. The conservation of baryon and lepton numbers follows as a prediction. Leptons and quarks correspond to opposite chiralities for imbedding space spinors.
- 3. What remains to be explained in standard model is family replication phenomenon for leptons and quarks. Both quarks and leptons appear as three families identical apart from having different masses. The conjecture was is that fermion families correspond to different topologies for 2-D surfaces characterized by genus telling the number g (genus) of handles attached to sphere to obtain the surface: sphere, torus, The 2-surfaces are identified as "partonic 2-surfaces" whose orbits are light-like 3-surface at which the signature of the induced metric of space-time surface transforms from Minkowskian to Euclidian. The partonic orbits replace the lines of Feynman diagrams in TGD Universe in accordance with the replacement of point-like particle with 2-surface.

Only the three lowest genera are observed experimentally. A possible explanation is in terms of conformal symmetries: the genera $g \leq 2$ allow always Z_2 as a subgroup of conformal symmetries (hyper-ellipticity) whereas higher genera in general do not. The handles of partonic 2-surfaces could form analogs of unbound many-particle states for g > 2 with a continuous spectrum of mass squared but for g = 2 form a bound state by hyper-ellipticity [K36].

4. Later further arguments in favor of $H = M^4 \times CP_2$ have emerged. One of them relates to twistorialization and twistor lift of TGD [K132, K57, K19]. 4-D Minkowski space is unique space-time with Minkowskian signature of metric in the sense that it allows twistor structure. This is a problem in attempts to introduce twistors to General Relativity Theory (GRT) and a serious obstacle in the quantization based on twistor Grassmann approach, which has demonstrate its enormous power in the quantization of gauge theories. In TGD framework one can ask whether one could lift also the twistor structure to the level of H. M^4 has twistor structure and so does also CP_2 : which is the only Euclidian 4-manifold allowing twistor space, which is also a Kähler manifold! This led to the notion of twistor lift of TGD inducing rather recent breakthrough in the understanding of TGD.

TGD can be also seen as a generalization of hadronic string model - not yet superstring model since this model became fashionable two years after the thesis about TGD [K4]. Later it has become clear that string like objects, which look like strings but are actually 3-D are basic stuff of TGD Universe and appear in all scales [K40, K14]. Also strictly 2-D string world sheets popped up in the formulation of quantum TGD (analogy with branes) [?] that one can say that string model in 4-D space-time is part of TGD.

Concluding, TGD generalizes standard model symmetries and provides an incredibly simple proposal for a dynamics: only 4 classical field variables and in fermionic sector only quark and lepton like spinor fields. The basic objection against TGD looks rather obvious in the light of afterwisdom. One loses linear superposition of fields, which holds in good approximation in ordinary field theories, which are almost linear. The solution of the problem to be discussed later relies on the notion many-sheeted space-time [K29].

Many-sheeted space-time

The replacement of the abstract manifold geometry of general relativity with the geometry of 4surfaces brings in the shape of surface as seen from the perspective of 8-D space-time as additional degrees of freedom giving excellent hopes of realizing the dream of Einstein about geometrization of fundamental interactions.

The work with the generic solutions of the field equations assignable to almost any variational principle satisfying GCI led soon to the realization that the topological structure of space-time in this framework is much more richer than in GRT.

1. Space-time decomposes into space-time sheets of finite size. This led to the identification of physical objects that we perceive around us as space-time sheets. The original identification of space-time sheet was as a surface of in H with outer boundary. For instance, the outer boundary of the table would be where that particular space-time sheet ends (what "ends" means is not however quite obvious!). We would directly see the complex topology of many-sheeted space-time! Besides sheets also string like objects and elementary particle like objects appear so that TGD can be regarded also as a generalization of string models obtained by replacing strings with 3-D surfaces.

It turned that boundaries are probably excluded by boundary conditions. Rather, two sheets with boundaries must be glued along their boundaries together to get double covering. Sphere can be seen as simplest example of this kind of covering: northern and southern hemispheres are glued along equator together.

2. The original vision was that elementary particles are topological inhomogenities glued to these space-time sheets using topological sum contacts. This means drilling a hole to both sheets and connecting with a very short cylinder. 2-dimensional illustration should give the idea. In this conceptual framework material structures and shapes would not be due to some mysterious substance in slightly curved space-time but reduce to space-time topology just as energy- momentum currents reduce to space-time curvature in GRT.

This view has gradually evolved to much more detailed picture. Elementary particles have wormhole contacts as basic building bricks. Wormhole contact is very small region with *Euclidian (!)* signature of the induced metric connecting two Minkowskian space-time sheets with light-like boundaries carrying spinor fields and there particle quantum numbers. Wormhole contact carries magnetic monopole flux through it and there must be second wormhole contact in order to have closed lines of magnetic flux. Particle world lines are replaced with 3-D light-like surfaces - orbits of partonic 2-surfaces - at which the signature of the induced metric changes.

One might describe particle as a pair of magnetic monopoles with opposite charges. With some natural assumptions the explanation for the family replication phenomenon in terms of the genus g of the partonic 2-surface is not affected. Bosons emerge as fermion anti-fermion pairs with fermion and anti-fermion at the opposite throats of the wormhole contact. In principle family replication phenomenon should have bosonic analog. This picture assigns to particles strings connecting the two wormhole throats at each space-time sheet so that string model mathematics becomes part of TGD.

The notion of classical field differs in TGD framework in many respects from that in Maxwellian theory.

1. In TGD framework fields do not obey linear superposition and all classical fields are expressible in terms of four imbedding space coordinates in given region of space-time surface. Superposition for classical fields is replaced with *superposition of their effects* [K128, K146] - in full accordance with operationalism. Particle can topologically condense simultaneously to several space-time sheets by generating topological sum contacts (not stable like the wormhole contacts carrying magnetic monopole flux and defining building bricks of particles). Particle "experiences" the superposition of the effects of the classical fields at various space-time sheets rather than the superposition of the fields.

It is also natural to expect that at macroscopic length scales the physics of classical fields (to be distinguished from that for field quanta) can be explained using only four primary field like variables. Electromagnetic gauge potential has only four components and classical electromagnetc fields give and excellent description of physics. This relates directly to electroweak symmetry breaking in color confinement which in standard model imply the effective absence of weak and color gauge fields in macroscopic scales. TGD however predicts that copies of hadronic physics and electroweak physics could exist in arbitrary long scales [K81] and there are indications that just this makes living matter so different as compared to inanimate matter. 2. The notion of induced gauge field means that one induces electroweak gauge potentials defining so called spinor connection at space-time surface (induction of bundle structure). Induction boils down locally to a projection of the imbedding space vectors representing the spinor connection. The classical fields at the imbedding space level are non-dynamical and fixed and extremely simple: one can say that one has generalization of constant electric field and magnetic fields in CP_2 . The dynamics of the 3-surface however implies that induced fields can form arbitrarily complex field patterns. This is essentially dynamics of shadows.

Induced gauge fields are not equivalent with ordinary free gauge fields. For instance, the attempt to represent constant magnetic or electric field as a space-time time surface has a limited success. Only a finite portion of space-time carrying this field allows realization as 4-surface. I call this topological field quantization. The magnetization of electric and magnetic fluxes is the outcome. Also gravitational field patterns allowing imbedding are very restricted: one implication is that topological with over-critical mass density are not globally imbeddable. This would explain why the mass density in cosmology can be at most critical. This solves one of the mysteries of GRT based cosmology [K119].

Quite generally, the field patterns are extremely restricted: not only due to imbeddability constraint but also due to the fact that by SH only very restricted set of space-time surfaces can appear solutions of field equations: I speak of preferred extremals (PEs) [K14, K21, K29]. One might speak about archetypes at the level of physics: they are in quite strict sense analogies of Bohr orbits in atomic physics: this is implies by the realization of GCI. This kind of simplicity does not conform with what we observed. The way out is many-sheeted space-time. Although fields do not superpose, particles experience the superposition of effects from the archetypal field configurations (superposition is replaced with set theoretic union).

3. The important implication is that one can assign to each material system a field identity since electromagnetic and other fields decompose to topological field quanta. Examples are magnetic and electric flux tubes and flux sheets and topological light rays representing light propagating along tube like structure without dispersion and dissipation making em ideal tool for communications [K91]. One can speak about field body or magnetic body of the system.

Field body indeed becomes the key notion distinguishing TGD inspired model of quantum biology from competitors but having applications also in particle physics since also leptons and quarks possess field bodies. The is evidence for the Lamb shift anomaly of muonic hydrogen [C1] and the color magnetic body of u quark whose size is somewhat larger than the Bohr radius could explain the anomaly [K82]. The magnetic flux tubes of magnetic body carry monopole fluxes existing without generating currents. In cosmology the flux tubes assignable to the remnants of cosmic strings make possible long range magnetic fields in all scales impossible in standard cosmology. Also super-conductivity is proposed to rely on dark $h_{eff} = n \times h$ Cooper pairs at pairs of flux tubes carrying monopole flux.

GRT and gauge theory limit of TGD is obtained as an approximation.

1. GRT/gauge theory type description is an approximation obtained by lumping together the space-time sheets to single region of M^4 , with gravitational fields and gauge potentials as sums of corresponding induced field quantities at space-time surface geometrized in terms of geometry of H. Gravitational field corresponds to the deviation of the induced metric from Minkowski metric using M^4 coordinates for space-time surface so that the description applies only in long length scale limit.

Space-time surface has both Minkowskian and Euclidian regions. Euclidian regions are identified in terms of what I call generalized scattering/twistor diagrams. The 3-D boundaries between Euclidian and Minkowskian regions have degenerate induced 4-metric and I call them light-like orbits of partonic 2-surfaces or light-like wormhole throats analogous to blackhole horizons. The interiors of blackholes are replaced with the Euclidian regions and every physical system is characterized by this kind of region.

Lumping of sheets together implies that global conservation laws cannot hold exactly true for the resulting GRT type space-time. Equivalence Principle (EP) as Einstein's equations stating conservation laws locally follows as a local remnant of Poincare invariance. 2. Euclidian regions are identified as slightly deformed pieces of CP_2 connecting two Minkowskian space-time regions. Partonic 2-surfaces defining their boundaries are connected to each other by magnetic flux tubes carrying monopole flux.

Wormhole contacts connect two Minkowskian space-time sheets already at elementary particle level, and appear in pairs by the conservation of the monopole flux. Flux tube can be visualized as a highly flattened square traversing along and between the space-time sheets involved. Flux tubes are accompanied by fermionic strings carrying fermion number. Fermionic strings give rise to string world sheets carrying vanishing induced em charged weak fields (otherwise em charge would not be well-defined for spinor modes). String theory in spacetime surface becomes part of TGD. Fermions at the ends of strings can get entangled and entanglement can carry information.

3. Strong form of GCI (SGCI) states that light-like orbits of partonic 2-surfaces on one hand and space-like 3-surfaces at the ends of causal diamonds on the other hand provide equivalent descriptions of physics. The outcome is that partonic 2-surfaces and string world sheets at the ends of CD can be regarded as basic dynamical objects.

Strong form of holography (SH) states the correspondence between quantum description based on these 2-surfaces and 4-D classical space-time description, and generalizes AdS/CFT correspondence. One has huge super-symplectic symmetry algebra acting as isometries of WCW with conformal structure [K39, K109, K144], conformal algebra of light-cone boundary extending the ordinary conformal algebra, and ordinary Kac-Moody and conformal symmetries of string world sheets. This explains why 10-D space-time can be replaced with ordinary space-time and 4-D Minkowski space can be replaced with partonic 2-surfaces and string world sheets. This holography looks very much like the one we are accustomed with!

5.2.2 Zero energy ontology (ZEO)

In standard ontology of quantum physics physical states are assumed to have positive energy. In zero energy ontology (ZEO) [K85] physical states decompose to pairs of positive and negative energy states such that the net values of the conserved quantum numbers vanish. The interpretation of these states in ordinary ontology would be as transitions between initial and final states, physical events.

ZEO and positive energy ontology

ZEO is consistent with the crossing symmetry of QFTs meaning that the final states of the quantum scattering event can be described formally as negative energy states. As long as one can restrict the consideration to either positive or negative energy part of the state ZEO is consistent with positive energy ontology. This is the case when the observer characterized by a particular CD studies the physics in the time scale of much larger CD containing observer's CD as a sub-CD. When the time scale sub-CD of the studied system is much shorter that the time scale of sub-CD characterizing the observer, the interpretation of states associated with sub-CD is in terms of quantum fluctuations.

ZEO solves the problem, which emerges in any theory assuming symmetries giving rise to conservation laws. The problem is that the theory itself is not able to characterize the values of conserved quantum numbers of the initial state of say cosmology. In ZEO this problem disappears since in principle any zero energy state is obtained from any other state by a sequence of quantum jumps without breaking of conservation laws. The fact that energy is not conserved in GRT based cosmologies can be also understood since each CD is characterized by its own conserved quantities. As a matter fact, one must speak about average values of conserved quantities since one can have a quantum superposition of zero energy states with the quantum numbers of the positive energy part varying over some range.

At the level of principle the implications are quite dramatic. In quantum jump as recreation replacing the quantum Universe with a new one it is possible to create entire sub-universes from vacuum without breaking the fundamental conservation laws. From the point of view of consciousness theory the important implication is that "free will" is consistent with the laws of physics. This makes obsolete the basic arguments in favor of materialistic and deterministic world view.

Zero energy states are located inside causal diamond (CD)

By quantum classical correspondence zero energy states must have space-time and imbedding space correlates.

1. Positive and negative energy parts of zero energy state reside at future and past light-like boundaries of causal diamond (CD) identified as intersection of future and past directed light-cones and visualizable as double cone. The analog of CD in cosmology is big bang followed by big crunch. Penrose diagrams provide an excellent 2-D visualization of the notion. CDs form a fractal hierarchy containing CDs within CDs. Disjoint CDs are possible and CDs could also intersect.

The interpretation of CD in TGD inspired theory of consciousness is as an imbedding space correlate for perceptive field of conscious entity: the contents of conscious experience is about the region defined by CD. At the level of space-time sheets the experience come from spacetime sheets in the interior of CD. Whether the sheets can be assumed to continue outside CD is still unclear.

Quantum measurement theory must be modified in ZEO since state function reduction can happen at both boundaries of CD and the reduced states at opposite boundaries are related by time reversal. One can also have quantum superposition of CDs changing between reductions at active boundary followed by localization in the moduli space of CDs with the tip of passive boundary fixed. Quantum measurement theory generalizes to a theory of consciousness with continuous entity identified as a sequence of state function reductions at active (changing) boundary of CD [K13].

2. By number theoretical universality (NTU) the temporal distances between the tips of the intersecting light-cones are assumed to come as integer multiples $T = m \times T_0$ of a fundamental time scale T_0 defined by CP_2 size R as $T_0 = R/c$. p-Adic length scale hypothesis [K87, K142] motivates the stonger hypothesis that the distances tend to come as as octaves of T_0 : $T = 2^n T_0$. One prediction is that in the case of electron this time scale is .1 seconds defining the fundamental biorhythm. Also in the case u and d quarks the time scales correspond to biologically important time scales given by 10 ms for u quark and by and 2.5 ms for d quark [K17]. This means a direct coupling between microscopic and macroscopic scales.

5.2.3 Quantum physics as physics of classical spinor fields in WCW

The notions of Kähler geometry of "World of Classical Worlds" (WCW) and WCW spinor structure are inspired by the vision about the geometrization of the entire quantum theory.

Motivations for WCW

The notion of "World of Classical Worlds" (WCW) [K65, K39, K109] was forced by the failure of both path integral approach and canonical quantization in TGD framework. The idea is that the Kähler function defining WCW Kähler geometry is determined by the real part of an action S determining space-time dynamics and receiving contributions from both Minkowskian and Euclidian regions of space-time surface X^4 (note that $\sqrt{g_4}$ is proportional to imaginary unit in Minkoskian regions).

- 1. If S is space-time volume both canonical quantization and path integral would make sense at least formally since in principle one could solve the time derivatives of four imbedding space coordinates as functions of canonical momentum densities (general coordinate invariance allows to eliminate four coordinates). The calculation of path integral is however more or less hopeless challenge in practice.
- 2. A mere space-time volume as action is however not physically attractive. This was thought to leave under consideration only Kähler action S_K - Maxwell action for the induced Kähler form expressible in terms of gauge potential defined by the induced Kähler gauge potential of CP_2 . This action has however a huge vacuum degeneracy. Any space-time surface with at most 2-D CP_2 projection, which is Lagrangian sub-manifold of CP_2 , is vacuum extremal.

Symplectic transformations acting like U(1) gauge transformations generate new vacuum extremals. They however fail to act as symmetries of non-vacuum extremals so that gauge invariance is not in question: the deviation of the induced metric from flat metric is the reason for the failure. This degeneracy is assumed to give rise to what might be called 4-D spin glass degeneracy meaning that the landscape for the maxima of Kähler function is fractal.

3. Canonical quantization fails because by the extreme non-linearity of the action principle making it is impossible to solve time derivatives explicitly in terms of canonical momentum densities. The problem is especially acute for the canonical imbedding of empty Minkowski space to $M^4 \times CP_2$. The action is vanishing up to fourth order in imbedding space coordinates so that canonical momentum densities vanish identically and there is no hope of defining propagator in path integral approach. The mechanical analog would be criticality around which the potential reduces to $V \propto x^4$. Quantum criticality is indeed a basic aspect of TGD Universe.

The hope held for a long time was that WCW geometry allowing to get rid of path integral would solve the problems. One could however worry about vacuum degeneracy implying that WCW metric becomes extremely degenerate for vacuum extremals and also holography becomes extremely non-unique for them. Also the expected feailure of perturbative approach around M^4 is troublesome.

WCW and twistor lift of TGD

During last year this picture has indeed changed thanks to what might be called twistor lift of TGD [K132, K57, K19] inspired by twistor Grassmann approach to supersymmetric gauge theories [B11]. Remarkably, twistor lift would provide automatically the fundamental couplings of standard model and GRT and also the scale assigned to GUTs as CP_2 radius. PEs would be both extremals of Kähler action and minimal surfaces.

- 1. The basic observation is E^4 , and its Euclidian compactification S^4 and CP_2 are completely unique in that they allow twistor space with Kähler structure [A27]. This was discovered by Hitchin at roughly the same time as I discovered TGD! This generalizes to M^4 having a generalization of ordinary Kähler structure to what I have called Hamilton-Jacobi structure by decomposition $M^4 = M^2 \times E^2$, where M^2 allows hypercomplex structure [K132, K57]. One can consider also integral distributions of tangent decompositions $M^4 = M^2(x) \times E^2(x)$, depending on position. The twistor space has a double fibration by S^2 with base spaces identifiable as M^4 and conformal compactification of M^4 for which metric is defined only up to conformal scaling. The first fibration $M^4 \times S^2$ with a well-defined metric would correspond to the classical TGD.
- 2. Both Newton's constant G and cosmological constant Λ emerge from twistor lift in M^4 factor. The radius of S^2 is identified in terms of Planck length $l_P = \sqrt{G}$. For CP_2 factor, the radius corresponds to the radius of CP_2 geodesic sphere. 4-D Kähler action can be lifted to 6-D Kähler action only for $M^4 \times CP_2$ so that TGD would be completely unique both mathematically and physically. The twistor space of CP_2 is flag-manifold $SU(3)/U(1) \times U(1)$ having interpretation as the space for the choices of quantization axis of color isospin and hypercharge. This choice could correspond to a selection of Eguchi-Hanson complex coordinates for CP_2 by fixing their phase angles in which isospin and hypercharge rotations induce shifts.
- 3. The physically motivated conjecture is that the PEs can be lifted to their 6-D twistor bundles with S^2 serving as a fiber, that one induce the twistor structure and the outcome is equal to the twistor structure of space-time surface, and that this condition is at least part of the PE property. This would correspond to the solution of massless wave equations in terms of twistors in the original twistor approach of Penrose [B24]. The analog of spontaneous compactification would lead to 4-D action equal to Kähler action plus volume term. One could of course postulate this action directly without mentioning twistors at all.

The coefficient of the volume term would correspond to dark energy density characterized by cosmological constant Λ being extremely small in cosmological scales. It removes vacuum degeneracy although the situation remains highly non-perturbative. This can be combined with the earlier conjecture that cosmological constant Λ behaves as $\Lambda \propto 1/p$ under p-adic coupling constant evolution so that Λ would be large in primordial cosmology.

4. The generic extremals of space-time action would depend on coupling parameters, which does not fit with the number theoretic vision inspiring speculations that space-time surface can be seen as quaternionic sub-manifolds of 8-D octonionic space-time [K126], satisfying quaternion analyticity [K57], or a 4-D generalization of holomorphy. By SH the extremals are however "preferred". What could this imply?

Intriguingly, all known non-vacuum extremals and also CP_2 type vacuum extremals having null-geodesic as M^4 projection are extremals of both Kähler action and volume term separately! The dynamics for volume term and Kähler action effectively decouple and coupling constants do not appear at all in field equations. The twistor lift would only select minimal surface amongst vacuum extremals, modify the Kähler function of WCW identifiable as exponent for the real part of action, and provide a profound mathematical and physical motivation for cosmological constant Λ remaining mysterious GRT framework. One could even hope that preferred extremals are nothing but minimal surface extremals of Kähler action with the vanishing conditions for some sub-algebra of super-symplectic algebra satisfied automatically!

The analog of decoupling of Kähler action and volume term should take place also for induced spinors. This is expected if mere analyticity properties make spinor modes solutions of modified Dirac equations. This is true in 2-D case Hamilton-Jacobi structure should guarantee this in 4-D case [K144, K57].

PEs depend on coupling parameters only via boundary conditions stating the vanishing of Noether charges for a sub-algebra of super-symplectic algebra and its commutator with entire algebra. Also the conservation conditions at 3-D light-like surfaces at which the signature of metric changes imply dependence on coupling parameters. These conditions allow the transfer of classical charges between Minkowskian and Euclidian regions necessary to understand momentum exchange between particles and environment classically only if Kähler couplings strength is complex - otherwise there is no exchange of conserved quantities since their real *resp.* imaginary at the two sides [K54]. Interestingly, also in twistor Grassmann approach the massless poles in propagators are complex.

This picture conforms with the conjecture that discrete p-adic evolution of the Kähler coupling strength in subset of primes near prime powers of two corresponds to complex zeros of zeta [K54]. This conforms also with the conjectured discreteness of p-adic coupling constant evolution by phase transitions changing the values of coupling parameters. One implication is that all loop corrections in functional integral vanish.

5. In path integral approach quantum TGD would be extremely non-perturbative around extremals for which Kähler action vanishes. Same is true also in WCW approach. The cure would be provided by the hierarchy of Planck constants $h_{eff}/h = n$, which effectively scales Λ down to Λ/n . n would be the number sheets of the M^4 covering defined by the space-time surface: the action of Galois group for the number theoretic discretization of space-time surface could give rise to this covering. The finiteness of the volume term in turn forces ZEO: the volume of space-time surface is indeed finite due to the finite size of CD.

Consider now the delicacies of this picture.

1. Should assign also to M^4 the analog of symplectic structure giving an additional contribution to the induced Kähler form? The symmetry between M^4 and CP_2 suggests this, and this term could be highly relevant for the understanding of the observed CP breaking and matter antimatter asymmetry [L78]. Poincare invariance is not lost since the needed moduli space for M^4 Kähler forms would be the moduli space of CDs forced by ZEO in any case, and M^4 Kähler form would serve as the correlate for fixing rest system and spin quantization axis in quantum measurement. 2. Also induced spinor fields are present. The well-definedness of electro-magnetic charge for the spinor modes forces in the generic case the localization of the modes of induced spinor fields at string world sheets (and possibly to partonic 2-surfaces) at which the induced charged weak gauge fields and possibly also neutral Z^0 gauge field vanish. The analogy with branes and super-symmetry force to consider two options.

Option I: The *fundamental* action principle for space-time surfaces contains besides 4-D action also 2-D action assignable to string world sheets, whose topological part (magnetic flux) gives rise to a coupling term to Kähler gauge potentials assignable to the 1-D boundaries of string world sheets containing also geodesic length part. Super-symplectic symmetry demands that modified Dirac action has 1-, 2-, and 4-D parts: spinor modes would exist at both string boundaries, string world sheets, and space-time interior. A possible interpretation for the interior modes would be as generators of space-time super-symmetries [K115].

This option is not quite in the spirit of SH and string tension appears as an additional parameter. Also the conservation of em charge forces 2-D string world sheets carrying vanishing induced W fields and this is in conflict with the existence of 4-D spinor modes unless they satisfy the same condition. This looks strange.

Option II: Stringy action and its fermionic counterpart are effective actions only and justified by SH. In this case there are no problems of interpretation. SH requires only that the induced spinor fields at string world sheets determine them in the interior much like the values of analytic function at curve determine it in an open set of complex plane. At the level of quantum theory the scattering amplitudes should be determined by the data at string world sheets. If induced W fields at string world sheets are vanishing, the mixing of different charge states in the interior of X^4 would not make itself visible at the level of scattering amplitudes! In this case 4-D spinor modes do not define space-time super-symmetries.

3. Why the string world sheets coding for effective action should carry vanishing weak gauge fields? If M^4 has the analog of Kähler structure [L78], one can speak about Lagrangian sub-manifolds in the sense that the sum of the symplectic forms of M^4 and CP_2 projected to Lagrangian sub-manifold vanishes. Could the induced spinor fields for effective action be localized to generalized Lagrangian sub-manifolds? This would allow both string world sheets and 4-D space-time surfaces but SH would select 2-D Lagrangian manifolds. At the level of effective action the theory would be incredibly simple.

Induced spinor fields at string world sheets could obey the "dynamics of avoidance" in the sense that *both* the induced weak gauge fields W, Z^0 and induced Kähler form (to achieve this U(1) gauge potential must be sum of M^4 and CP_2 parts) would vanish for the regions carrying induced spinor fields. They would coupleonly to the *induced em field* (!) given by the R_{12} part of CP_2 spinor curvature [L2] for D = 2, 4. For D = 1 at boundaries of string world sheets the coupling to gauge potentials would be non-trivial since gauge potentials need *not* vanish there. Spinorial dynamics would be extremely simple and would conform with the vision about symmetry breaking of weak group to electromagnetic gauge group.

The projections of canonical currents of Kähler action to string world sheets would vanish, and the projections of the 4-D modified gamma matrices would define just the induced 2-D metric. If the induced metric of space-time surface reduces to an orthogonal direct sum of string world sheet metric and metric acting in normal space, the flow defined by 4-D canonical momentum currents is parallel to string world sheet. These conditions could define the "boundary" conditions at string world sheets for SH.

This admittedly speculative picture has revolutionized the understanding of both classical and quantum TGD during last year. [K57, K19, K29]. In particular, the construction of singlesheeted PEs as minimal surfaces allows a kind of lego like engineering of more complex PEs [L43]. The minimal surface equations generalize Laplace equation of Newton's gravitational theory to non-linear massless d'Alembert equation with gravitational self-coupling. One obtains the analog of Schwartschild solution and radiative solutions describing also gravitational radiation [K29]. An open question is whether classical theory makes sense if also the analog of Kähler form in M^4 is allowed.

Identification of WCW

The notion of WCW [K65, K39, K109] was inspired by the super-space approach of Wheeler in which 3-geometries are the basic geometric entities.

1. In TGD framework 3-surfaces take this role. Einstein's program for geometrizing classical physics is generalized to a geometrization of entire quantum physics. Hermitian conjugation corresponds to complex conjugation in infinite-dimensional context so that WCW must have Kähler geometry. The geometrization of fermionic statistics/oscillator operators is in terms of gamma matrices of WCW expressible as linear combinations of oscillator operators for second quantized induced spinor field. Formally purely classical spinor modes of WCW represent many fermion states as functionals of 3-surface. One can also interpret gamma matrices as generators of super-conformal symmetries in accordance with the fact that also SUSY involves Clifford algebra.

In ZEO the entanglement coefficients between positive and negative energy parts of zero energy states determine the S-matrix so that S-matrix would be coded by the modes of WCW spinor fields. Twistor approach to TGD [K57] suggests that the S-matrix reduces completely to the symmetries defined by the multi-local (locus corresponds to partonic 2-surface) generators of the Yangian associated with the super-symplectic algebra.

- 2. ZEO forces to identify 3-surfaces as pairs of 3-surfaces with members at the opposite boundaries of CD. SH reduces them to a collection of partonic 2-surfaces at boundaries of CD plus number theoretic discretization in space-time interior. Basic geometric objects are pairs of initial and final states (coordinates for both in mechanical analogy) rather than initial states with initial value conditions (coordinates and velocities in mechanical analogy) and initial value problem transforms to boundary value problem. Processes rather than states become the basic elements of ontology: this has far reaching consequences in biology and neuroscience.
- 3. The realization of GCI requires that the definition of WCW Kähler function assigns to a "physically" 3-surface a unique 4-surface for 4-D general coordinate transformations to act: "physically" could mean "apart from transformations acting as gauge transformations" not affecting the action and conserved classical charges. The outcome is holography.
- 4. Strong form of holography (SH) would emerge as follows. The condition that light-like 3surfaces defining boundaries between Euclidian and Minkowskian regions are basic geometric entities equivalent with pairs of space-like 3-surfaces at the ends of given causal diamond CD implies SH: partonic 2-surfaces and their 4-D tangent space data should code the physics. One could also speak about almost/effective 2-dimensionality. Tangent space data could in turn be coded by string world sheets. Number theoretical discretitization of space-time interior with preferred coordinates in the extension of rationals could give meaning for "almost".
- 5. Kähler metric is expressible both in terms of second derivatives of Kähler function K [K65] and as anticommutators of WCW gamma matrices expressible as linear combinations of fermionic oscillator operators. This suggests a close relationship between space-time dynamics and spinor dynamics.

Super-symplectic symmetry between the action defining space-time surfaces (Kähler action plus volume term) and modified Dirac action would realize this relationship. This is achieved if the modified gamma matrices are defined by the canonical momentum currents of 2-D action associated with string world sheets. These currents are parallel to the string world sheets. This implies the analog of AdS/CFT correspondence requiring only that induced spinor modes at string world sheets determine them in space-time interior (this is like analytic continuation). The localization of spinor modes at string world sheets is *not* required as I believed first.

The geometry of loop spaces developed by Freed [A17] serves as a model in the construction of WCW Kähler geometry [K109].

- 1. The existence of loop space Riemann connection requires maximal isometry group identifiable as Kac-Moody group so that Killing vector fields span the entire tangent space of the loop space.
- 2. In TGD framework the properties of Kähler action lead to the idea that WCW is union of homogenous or even symmetric spaces of symplectic algebra acting at the boundary of $\delta CD \subset \delta CD_+ \cup \delta CD_-$, $\delta CD_\pm \subset \delta M_\pm^4 \times CP_2$. ZEO requires that the conserved quantum numbers for physical states are opposite for the positive and negative energy parts of the states at the two opposite boundary parts of CD. The symmetric spaces G/H in the union are labelled by zero modes, which do not appear in the line element as differentials but only as parameters of the metric. Conserved Noether charges of isometries and symplectic invariants of examples of zero modes as also the super-symplectic Noether charges invariant under complex conjugation of WCW coordinates.
- 3. Homogenous spaces of the symplectic group G are obtained by dividing by a subgroup H. An especially attractive option is suggested by the fractal structure of the symplectic algebra containing an infinite hierarchy of sub-algebras G_n for which conformal weights are n > 0multiples of those for G. For this option $H = G_n$ is isomorphic to G and one could have infinite hierarchies of inclusions analogous to the hierarchy of inclusions of hyperfinite factors of type II_1 (HFFs). PE property requires almost 2-dimensionality and elimination of huge number of degrees of freedom. The natural condition is that the Noether charges of G_n vanish at the ends of CD. A stronger condition is that also the Noether charges for $[G, G_n]$ vanish. This implies effective normal algebra property and G/G_n acts effectively like group.

The inclusion of HFFs would define measurement resolution with included factor acting like gauge algebra. Measurement resolution would be naturally determined by the number theoretic discretization of the space-time surface so that physics as geometry and number theory visions would meet each other.

4. This inclusion hierarchy can be identified in terms of quantum criticality (QC). The transitions $n \to kn$ increasing the value of n > 0 reduce QC since pure gauge symmetries are reduced, and new physical super-symplectic degrees of freedom emerge. QC also requires that Kähler couplings strength analogous to temperature is analogous to critical temperature so that the quantum theory is uniquely defined if their is only one critical temperature. Spectrum for α_K seems more plausible and the possibility that Kähler coupling strength depends on the level of the number theoretical hierarchy defined by the allowed extensions of rationals can be considered [K54].

WCW spinor structure

The basic idea is geometrization of quantum states by identifying them as modes of WCW spinor fields [K144, K109]. This requires definition of WCW spinors and WCW spinor structure, WCW gamma matrices and Dirac operator, etc..

The starting point is the definition of WCW gamma matrices using a representation analogous to the usual vielbein representation as linear combinations of flat space gamma matrices. The conceptual leap is the observation that there is no need to assume that the counterparts of flat space gamma matrices have vectorial quantum numbers. Instead, they are identified as fermionic oscillator operators for second quantized free induced spinor fields at space-time surface.

This allows geometrization of the fermionic statistics since WVW spinors for a given 3surface are analogous to fermionic Fock states. One can also say that spinor structure follows as a square root of metric and also that the spinor basis defines a geometric correlate of Boolean mind [K35]. The dependence of WCW spinor field on 3-surface represents the bosonic degrees of freedom not reducible to many-fermion states. For instance, most of hadron mass would be associated with these degrees of freedom.

Quantum TGD involves Dirac equations at space-time level, imbedding space level, and level of WCW. The dynamics of the induced spinor fields is related by super-symmetry to the action defining space-time surfaces as preferred extremals. [K144, K109].

1. The gamma matrices in the equation - modified gamma matrices - are determined by contractions of the canonical momentum currents of Kähler action with the imbedding space gamma matrices. The localization at string world sheets for which only induced neutral weak fields or only em field are non-vanishing is accompanied by the integrability condition that various conserved currents run along string world sheets: one can speak of sub-flow. I

2. Modified Dirac equation can be solved exactly just like in the case of string models using holomorphy and the properties of complexified modified gamma matrices. This is expected to be true also in 4-D case by Hamilton-Jacobi structure. If the dynamics of avoidance is realized the modified Dirac equation would be essentially free Dirac equation and holomorphy would allow to solve it.

At the level of WCW one obtains also the analog of massless Dirac equation as the analog of super Virasoro conditions of Super Virasoro algebra.

- 1. The fermionic counterparts of super-conformal gauge conditions assignable with sub-algebra G_n of supersymplectic conformal symmetry associated with the both light-cone boundary (light-like radial coordinate), with conformal symmetries of light-cone boundary, and with string world sheets.
- 2. The ground states of supersymplectic representations satisfy massless imbedding space Dirac equation in imbedding space so that Dirac equations in WCW, in imbedding space, and at string world sheets are involved. In twistorialization also massless M^8 Dirac equation emerges in the tangent space M^8 of imbedding space assignable to the partonic 2-surfaces and generalizes the 4-D light-likeness with its 8-D counterpart applying to states with M^4 mass. Here octonionic representation of imbedding space gamma matrices emerges naturally and allows to speak about 8-D analogs of Pauli's sigma matrices [K132].

5.2.4 Quantum criticality, measurement resolution, and hierarchy of Planck constants

The notions of quantum criticality (QC), finite measurement resolution, and hierarchy of Planck constants proposed to give rise to dark matter as phases of ordinary matter are central for TGD [?, K143, K55].

These notions relate closely to the strong form of holography (SH) implied by strong form of general coordinate invariance (SGCI). In adelic physics all this would relate closely to the hierarchy of extensions of rationals serving as a correlate for number theoretical evolution.

Finite measurement resolution and fractal inclusion hierarchy of super-symplectic algebras

The fractal hierarchy of isomorphic sub-algebras of supersymplectic algebra - call it g - defines an excellent candidate for the realization of finite the measurement resolution. Similar hierarchies can be assigned also for the extended super-conformal algebra assignable with light-like boundaries of CD and with Kac-Moody and conformal algebras assignable to string world sheets.

An interesting possibility is that the the conformal weights assignable to infinitesimal scaling operator of the light-like radial coordinate of light-cone boundary correspond to zeros of Riemann zeta [K142] [L39]. A kind of dual spectrum would correspond to conformal weights that correspond to logarithms for powers of primes. One can identify the conformal weight as negative of the pole of fermionic zeta $z_F = \zeta(s)/\zeta(2s)$ natural in TGD framework. The real part of conformal weight for the generators is $h_R = -1/4$ for "non-trivial" poles and positive integer h = n > 0 for "trivial" poles. There is also a pole for h = -1. Hence one obtains tachyonic ground states, which must be assumed also in p-adic mass calculations [K74].

Also the generators of Yangian algebra [K132] integrating the algebras assignable to various partonic 2-surfaces to a multi-local algebra are labelled by a non-negative integer n analogous to conformal weight and telling the number of partonic 2-surfaces involved with the action of the generator. Also this algebra has similar fractal hierarchy of sub-algebras so that the considerations that follow might apply also to it. Now that number of partonic 2-surface would play the role of measurement resolution.

As noticed, there are also other algebras, which allow conformal hierarchy if one can restrict the conformal weights to be non-negative. The first of them generates generalized conformal transformations of light-cone boundary depending on light-like radial coordinate as parameter: also now radial conformal weights for generators can have zeros of zeta as spectrum. As a special case one obtains infinite-dimensional group of isometries of light-cone boundary. Second one corresponds to ordinary conformal and Kac-Moody symmetries for induced spinor fields acting on string world sheets. Also here similar hierarchy of sub-algebras can be considered. In the following argument one restricts to super-symplectic algebra assumed to act as isometries of WCW.

Consider now how the finite measurement resolution could be realized as an infinite hierarchy of super-symplectic gauge symmetry breakings. The physical picture relies on quantum criticality of TGD Universe. The levels of the hierarchy labelled by positive integer n and a ball at the top of ball at... serves as a convenient metaphor.

1. The sub-algebra g_n for which conformal weights of generators (whose commutators give the sub-algebra) are positive integer multiples for those of the entire algebra g defines the algebra acting as pure gauge algebra defining a sub-group of symplectic group. The action of g_n as gauge algebra would mean that it affects on degrees of freedom below the measurement resolution. One can assign to this algebra a coset space G/G_n of the entire symplectic group G and of subgroup G_n . This coset space would describe the dynamical degrees of freedom. If the subgroup were a normal subgroup, the coset space would be a group. This is not the case now since the commutator $[g, g_n]$ of the entire algebra with the sub-algebra does not belong to g_n .

However, if one poses stronger - physically very attractive - gauge conditions stating that not only g_n but also the commutator algebra $[g, g_n]$ annihilates the physical states and that corresponding classical Noether charges vanish, one obtains effectively a normal subgroup and one has good hopes that coset space acts effectively as group, which is finite-dimensional as far as conformal weights are considered.

- 2. n > 0 is essential for obtaining effective normal algebra property. Without this assumption the commutator $[g, g_n]$ would be entire g. If the spectrum of supersymplectic conformal weights is integer valued it is not obvious why one should pose the restriction $n \ge 1$.
- 3. In this framework pure conformal invariance could reduce to a finite-dimensional gauge symmetry. A possible interpretation would be in terms of Mc-Kay correspondence [A35] assigning to the inclusions of HFFs labelled by integer $n \geq 3$ a hierarchy of simply laced Lie-groups. Since the included algebra would naturally correspond to degrees of freedom not visible in the resolution used, the interpretation as a dynamical gauge group is suggestive. The dynamical gauge group could correspond to *n*-dimensional Cartan algebra acting in conformal degrees of freedom identifiable as a simply laced Lie group. This would assign a infinite hierarchy of dynamical gauge symmetries to the broken conformal gauge invariance acting as symmetries of dark matter. This still leaves infinite number of degrees of freedom assignable to the imbedding space Hamiltonians and spectrum generated by zeros of zeta but this might have interpretation in terms of gauging so that additional vanishing conditions for Noether charges are suggestive.

Dark matter as large phases with large gravitational Planck constant $h_{eff} = h_{qr}$

D. Da Rocha and Laurent Nottale [E1] 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 [K117, K93].

1. The proposal is that a Schrödinger equation results from a fractal hydrodynamics. Manysheeted space-time however suggests that astrophysical systems are at some levels of the hierarchy of space-time sheets macroscopic quantum systems and that only the generalizations of Bohr orbits are involved. The space-time sheets in question would carry dark matter. 2. Nottale's hypothesis would predict a gigantic value of \hbar_{gr} . Equivalence Principle and the independence of gravitational Compton length $\Lambda_{gr} = \hbar_{gr}/m = GM/v_0 = 2r_S/v_0$ (typically astrophysical scale) 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 [K117].

One could criticize the hypothesis since it treats the masses M and m asymmetrically: this is only apparently true [?].

3. 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). The cross section of the flux tube corresponds to a sphere $S_i^2 \subset CP_2$, i = I, II [K19]. S_I^2 is homologically non-trivial carrying Kähler magnetic monopole flux. S_{II}^2 is homologically trivial carrying Kähler magnetic flux but non-vanishing electro-weak flux [K19].

The flux tubes of type I have both Kähler magnetic energy and dark energy due to the volume action. Flux tubes of type II would have only the volume energy. Both flux tubes could be remnants of cosmic string phase of primordial cosmology. The energy of these flux quanta would be correlated for galactic dark matter and volume action and also magnetic tension would give rise to negative "pressure" forcing accelerated 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 flux tubes identifiable also as dark energy.

4. Both theoretical consistency and certain experimental findings from astrophysics [E2, E5] and biology [L28, K20] suggest the identification $h_{eff} = n \times h = h_{gr}$. The large value of h_{gr} can be seen as a manner 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) [K109]. The values $h_{eff}/h = n$ 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 modified Dirac action is present, part of the interior degrees of freedom associated with the fermionic part of conformal algebra become physical.

Fermionic oscillator operators could generate super-symmetries and sparticles could correspond to dark matter with $h_{eff}/h = n > 1$. One implication would be that at least part if not all gravitons would be dark and be observed only through their decays to an ordinary high frequency graviton ($E = h f_{high} = h_{eff} f_{low}$) or to a bunch of n low energy gravitons.

Hierarchies of quantum criticalities, Planck constants, and dark matters

Quantum criticality is one of the corner stone assumptions of TGD. In the original approach the value of Kähler coupling strength α_K together with CP_7 radius R fixed quantum TGD and is analogous to critical temperature. Twistor lift [K19] brings in additional coupling constant Λ obeying p-adic coupling constant evolution and Planck length l_G , which like CP_2 radius would not obey coupling constant evolution (as also G). The values of these parameters should be fixed by quantum criticality. What else does quantum criticality mean is however far from obvious, and I have pondered the notion repeatedly both from the point of view of mathematical description and phenomenology [K65, K144, K109].

1. Criticality is characterized by long range correlations and sensitivity to external perturbations and living systems define an excellent example of critical systems - even in the scale of populations since without sensitivity and long range correlations cultural evolution and society would not be possible. For a physicist with the conceptual tools of existing theoretical physics the recent information society in which the actions of people at different side of globe are highly correlated, should look like a miracle. 2. The hierarchy of Planck constants with dark matter identified as phases of ordinary matter with non-standard value $h_{eff} = n \times h$ of Planck constant is one of the "almost-predictions" of TGD is definitely something essentially new physics. The phase transition transforming ordinary matter to dark matter in this sense generates long range quantal correlations and even macroscopic quantum coherence.

Finding of a universal mechanism generating dark matter have been a key challenge during last ten years. Could quantum criticality having classical or perhaps even thermodynamical criticality as its correlate be always accompanied by the generation of dark matter? If this were the case, the recipe would be stupifyingly simple: create a critical system! Dark matter would be everywhere and we would have observed its effects for centuries! Magnetic flux tubes (possibly carrying monopole flux) define the space-time correlates for long range correlations at criticality and would carry the dark matter. They are indeed key players in TGD inspired quantum biology.

- 3. Change of symmetry is assigned with criticality as also conformal symmetry (in 2-D case). In TGD framework conformal symmetry is extended and infinite hierarchy of breakings of conformal symmetry so that a sub-algebras of various conformal algebras with conformal weights coming as integer multiples of integer n defining h_{eff} would occur.
- 4. Phase separation is what typically occurs at criticality and one should understand also this. The strengthening of this hypothesis with the assumption $h_{eff} = h_{gr}$, where $h_{gr} = GMm/v_0$ is is the gravitational Planck constant originally introduced by Nottale [K95, ?]. In the formula v_0 has dimensions of velocity, and will be proposed to be determined by a condition relating the size of the system with mass M to the radius within which the wave function of particle m with $h_{eff} = h_{gr}$ is localized in the gravitational field of M.

The condition $h_{eff} = h_{gr}$ implies that the integer n in h_{eff} is proportional to the mass of the particle. The implication is that particles with different masses reside at flux tubes with different Planck constant and separation of phases indeed occurs.

5. What is remarkable is that neither gravitational Compton length nor cyclotron energy spectrum depends on the mass of the particle. This universality could play key role in living matter. One can assign Planck constant also to other interactions such as electromagnetic interaction so that one would have $h_{em} = Z_1 Z_2 e^2 / v_0$. The phase transition could take place when the perturbation series based on the coupling strength $\alpha = Z_1 Z_2 e^2 / \hbar$ ceases to converge. In the new phase perturbation series would converge since the coupling strength is proportional to $1/h_{eff}$. Hence criticality and separation into phases serve as criteria as one tries to see whether the earlier proposals for the mechanisms giving rise to large h_{eff} phases make sense. One can also check whether the systems to which large h_{eff} has been assigned are indeed critical.

One example of criticality is super-fluidity. Superfluids exhibit rather mysterious looking effects such as fountain effect [D26] and what looks like quantum coherence of superfluid containers, which should be classically isolated. These findings serve as a motivation for the proposal that genuine superfluid portion of superfluid corresponds to a large h_{eff} phase near criticality at least and that also in other phase transition like phenomena a phase transition to dark phase occurs near the vicinity [?].

But how does quantum criticality relate to number theory and adelic physics? $h_{eff}/h = n$ has been identified as the number of sheets of space-time surface identified as a covering space of some kind. Number theoretic discretization defining the "spine" for a monadic space-time surface [L56] defines also a covering space with Galois group for an extension of rationals acting as covering group. Could n be identifiable as the order for a sub-group of Galois group? If this is the case, the proposed rule for h_{eff} changing phase transitions stating that the reduction of n occurs to its factor would translate to spontaneous symmetry breaking for Galois group and spontaneous - symmetry breakings indeed accompany phase transitions.

TGD variant of AdS/CFT duality

AdS/CFT duality [B19] has provided a powerful approach in the attempts to understand the nonperturbative aspects of super-string theories. The duality states that conformal field theory in *n*-dimensional Minkowski space M^n identifiable as a boundary of n+1-dimensional space AdS_{n+1} is dual to a string theory in $AdS_{n+1} \times S^{9-n}$.

As a mathematical discovery AdS/CFT duality is extremely interesting but it seems that it need not have much to do with physics as such. From TGD point of view the reason is obvious: the notion of conformal invariance is quite too limited. In TGD framework conformal invariance is extended to a super-symplectic symmetry in $\delta M_{\pm}^4 \times CP_2$, whose Lie-algebra has the structure of conformal algebra. Also ordinary super-conformal symmetries associated with string world sheets are present as well as generalization of 2-D conformal symmetries to their analogs at light-cone boundary and light-like orbits of partonic 2-surfaces. In this framework AdS/CFT duality is expected to be modified.

The matrix elements $G_{K\overline{L}}$ of Kähler metric of WCW can be expressed in two manners. As contractions of the derivatives $\partial_K \partial_{\overline{L}} K$ of the Kähler function of WCW with isometry generators or as anticommutators $\{\Gamma_K, \Gamma_{\overline{L}}\}$ of WCW gamma matrices identified as supersymplectic Noether super charges assignable to fermionic strings connecting partonic 2-surfaces. Kähler function is identified as real part of the action: if coupling parameters are real it reduces to the action for the Euclidian space-time regions with 4-D CP_2 projection and otherwise contains contributions from both Minkowskian and Euclidian regions. The action defines the modified gamma matrices appearing in modified Dirac action as contractions of canonical momentum currents with imbedding space gamma matrices.

This observation suggests that there is a super-symmetry between action and modified Dirac action. The problem is that induced spinor fields naive of SH and also well-definedness of em charge demand the localization of induced spinor modes at 2-D string world sheets. This simply cannot be true. On the other hand, SH only requires that the data about induced spinor fields and space-time surface at the string world sheets is enough to construct the modes in space-time interior.

This leaves two options if one assumes that SH is exact (recall however that the number theoretic interpretation for the hierarchy of Planck constants suggests that the number-theoretic spin of monadic space-time surface represents additional discrete data needed besides that assignable to string world sheets to describe dark matter). As found in the section 5.2.3, there are two options.

Option I: The analog of brane hierarchy is realized at the level of fundamental action. There is a separate fundamental 2-D action assignable with string world sheets - area and topological magnetic flux term - as also world line action assignable to the boundaries of string world sheets. By previous argument string tension should be determined by the value of the cosmological constant Λ obeying -adic coupling constant evolution rather than by G: otherwise there is no hope about gravitationally bound states above Planck scale. String tension would appear as an additional fundamental coupling parameter (perhaps fixed by quantum criticality). This option does not quite conform with the spirit of SH.

Option II: 4-D space-time action and corresponding modified Dirac action defining fundamental actions are expressible as effective actions assignable to string world sheets and their boundaries. String world sheet effective action action could be expressible as string area for the effective metric defined by the anti-commutators of modified gamma matrices at string world sheet. If the sum of the induced Kähler forms of M^4 and CP_2 vanishes at string world sheets the effective metric would be the induced 2-D metric: this together with the observed CP breaking could provide a justification for the introduction of the analog of Kähler form in M^4 . String tension would be dynamical rather than determined by l_P and depend on Λ , l_P , R and α_K . This representation of Kähler action would be one aspect of the analog of AdS/CFT duality in TGD framework.

Both options would allow to understand how strings connecting partonic 2-surfaces give rise to the formation of gravitationally bound states. Bound states of macroscopic size are possible only if one allows hierarchy of Planck constants and this is required also by the (extremely) small value of Λ (in cosmic scales).

Consider the concerete realizations for this vision.

1. SGCI requires effective 2-dimensionality. In given UV and IR resolutions partonic 2-surfaces and string world sheets are assignable to a finite hierarchy of CDs inside CDs with given CD characterized by a discrete scale coming as an integer multiple of a fundamental scale (essentially CP_2 size). A would closely relate to the size scale of CD. String world sheets have boundaries consisting of either light-like curves in induced metric at light-like wormhole throats and space-like curves at the ends of CD whose M^4 projections are light-like. These braids carrying fermionic quantum numbers intersect partonic 2-surfaces at discrete points.

2. This implies a rather concrete analogy with $AdS_5 \times S_5$ duality, which describes gluons as open strings. In zero energy ontology (ZEO) string world sheets are indeed a fundamental notion and the natural conjecture is that these surfaces are minimal surfaces, whose area by quantum classical correspondence depends on the quantum numbers of the external particles.

String tension of gravitational flux tubes

For Planckian cosmic strings only quantum gravitational bound states of length of order Planck length are possible. There must be a mechanism reducing the string tension. The *effective* string tension assignable to magnetic flux tubes must be inversely proportional to $1/h_{eff}^2$, $h_{eff} = n \times h = h_{gr} = 2\pi GMm/v_0$ in order to obtain gravitationally bound states in macroscopic length scales identified as structures for which partonic 2-surfaces are connected by flux tubes accompanied by fermionic strings.

The reason is that the size scale of (quantum) gravitationally bound states of masses Mand m is given by grvitational Compton length $\Lambda_{gr} = GM/v_0$ [K117, K95, ?] assignable to the gravitational flux tubes connecting the masses M and m. If the string tension is of order Λ_{gr}^2 this is achieved since the typical length of string would be Λ_{gr} . Gravitational string tension must be therefore of order $T_{gr} \sim 1/\Lambda_{gr}^2$. How could this be achieved? One can imagine several options and here only the option based on the assumptions

- 1. Twistor lift makes sense.
- 2. Fundamental action is 4-D for both space-time and fermionic degrees of freedom and 2-D string world sheet action is an effective action realizing SH. Note effective action makes also possible braid statistics, which does not make sense at fundamental level.
- 3. Also M^4 carries the analog of Kähler form and the sum of induced Kähler forms from M^4 and CP_2 vanishes at string world sheets and also weak gauge fields vanishes at string world sheets leaving only em field.

is considered since it avoids all the objections that I have been able to invent.

For the twistor lift of TGD [K19] predicting cosmological constant Λ depending on p-adic length scale $\Lambda \propto 1/p$ the gravitational strings would be naturally homologically trivial cosmic strings. These vacuum extremals of Kähler action transform to minimal surface extremals with string tension given by $\rho_{vac}S$, where ρ_{vac} the density of dark energy assignable to the volume term of the action and S the transverse area of the flux tube. One should have $\rho_{vac}S = 8\pi\Lambda S/G = 1/\Lambda_{gr}^2$ so that one would have

$$8\pi\Lambda S = \frac{G}{\Lambda_{qr}^2}$$

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A for flux tubes (characterizing the size of CDs containing them) would depend on the gravitational coupling Mm.

5.2.5 Number theoretical vision

Physics as infinite-D spinor geometry of WCW and physics as generalized number theory are the two basic vision about TGD. The number theoretical vision involves three threads [K125, K126, K124].

 The first thread [K125] involves the notion of number theoretical universality NTU: quantum TGD should make sense in both real and p-adic number fields (and their algebraic extensions induced by extensions of rationals). p-Adic number fields are needed to understand the spacetime correlates of cognition and intentionality [K87, K58, K88].

p-Adic mass calcuations lead to the notion of a p-adic length scale hierarchy quantifying the notion of the many-sheeted space-time [K87, K58]. One of the first applications was the calculation of elementary particle masses [K74]. The basic predictions are only weakly model

independent since only p-adic thermodynamics for Super Virasoro algebra are involved. Not only the fundamental mass scales would reduce to number theory but also particle masses are predicted correctly under rather mild assumptions and are exponentially sensitive to the p-adic length scale predicted by p-adic length scale hypothesis. Also predictions such as the possibility of neutrinos to have several mass scales were made on the basis of number theoretical arguments and have found experimental support [K74, K36].

- 2. Second thread [K126] is inspired by the dimensions D = 1, 2, 4, 8 of the basic objects of TGD and assumes that classical number fields are in a crucial role in TGD. 8-D imbedding space would have octonionic structure and space-time surfaces would have associative (quaternionic) tangent space or normal space. String world sheets could correspond to commutative surfaces. Also the notion of $M^8 - H$ -duality is part of this thread and states that quaternionic 4-surfaces of M^8 containing preferred M^2 in its tangent space can be mapped to PEs in H by assigning to the tangent space CP_2 point parametrizing it. M^2 could be replaced by integrable distribution of $M^2(x)$. If PEs are also quaternionic one has also H - Hduality allowing to iterate the map so that PEs form a category. Also quaternion analyticity of PEs is a highly attractive hypothesis [K132]. For instance, it might be possible to interpret string world sheets and partonic 2-surfaces appearing in strong form of holography (SH) as co-dimension 2 surfaces analogous to poles of analytic function in complex plane. Light-like 3-surfaces might be seen as analogs of cuts. The coding of analytic function by its singularities could be seen as analog of SH.
- 3. The third thread [K124] corresponds to infinite primes and leads to several speculations. The construction of infinite primes is structurally analogous to a repeated second quantization of a supersymmetric arithmetic quantum field theory with free particle states characterized by primes. The many-sheeted structure of TGD space-time could reflect directly the structure of infinite prime coding it. Space-time point would become infinitely structured in various p-adic senses but not in real sense (that is cognitively) so that the vision of Leibniz about monads reflecting the external world in their structure is realized in terms of algebraic holography. Space-time becomes algebraic hologram and realizes also Brahman=Atman idea of Eastern philosophies.

5.3 p-Adic mass calculations and p-adic thermodynamics

p-Adic mass calculations carried for the first time around 1995 were the stimulus eventually leading to the number theoretical vision as a kind dual for the geometric vision about TGD. In this secton I will roughly describe the calculations [K36, K74] and the questions and challenges raised by them.

5.3.1 p-Adic numbers

Like real numbers, p-adic numbers (http://tinyurl.com/hmgqtoh) can be regarded as completions of the rational numbers to a larger number field [K58]. Each prime p defines a p-adic number field allowing the counterparts of the usual arithmetic operations.

1. The basic difference between real and p-adic numbers is that p-adic topology is ultra-metric. Ultrametricity means that the distance function d(x, y) (the counterpart of |x - y| in the real context) satisfies the inequality

$$d(x,z) \le Max\{d(x,y), d(y,z)\} ,$$

(Max(a, b) denotes maximum of a and b) rather than the usual triangle inequality

$$d(x,z) \le d(x,y) + d(y,z)$$

2. The topology defined by p-adic numbers is compact-open. Hence the generalization of manifold obtained by gluing together n-balls fails because smallest open n-balls are just points and one has totally disconnected topology.

- 3. p-Adic numbers are not well-ordered like real numbers. Therefore one cannot assign orientation to the p-adic number line. This in turn leads to difficulties with attempts to define definite integrals and the notion of differential form although indefinite integral is well-defined. These difficulties serve as important guidelines in the attempts to understand what p-adic physics is and also how to fuse real and various p-adic physics to a larger structure.
- 4. p-Adic numbers allow an expansion in powers of p analogous to the decimal expansion

$$x = \sum_{n \ge 0} x_n p^n$$

and the number of terms in the expansion can be infinite so that p-adic number need not be finite as a real number. The norm of the p-adic number (counterpart of |x| for real numbers) is defined as

$$N_p(x) = \sum_{n \ge 0} x_n p^n = p^{-n_0}$$

and depends only very weakly on p-adic number. The ultra-metric distance function can be defined as $d_p(x, y) = N_p(x - y)$.

5. p-Adic numbers allow a generalization of the differential calculus. The basic rules of the p-adic differential calculus are the same as those of the ordinary differential calculus. There is however one important new element: the set of the functions having vanishing p-adic derivative consists of so called pseudo constants, which are analogs of real valued piecewise constant functions. In the real case only constant functions have vanishing derivative. This implies that p-adic differential equations are non-deterministic. This non-determinism is identified as a counterpart of the non-determinism of cognition and imagination [K88].

5.3.2 Model of elementary particle

p-Adic mass calculations [K36, K74] rely heavily on a topological model for elementary particle and it is appropriate to describe it before going to the summary of calculations.

Family replication phenomenon topologically

One of the basic ideas of TGD approach to particle physics has been genus-generation correspondence: boundary components of the 3-surface should be carriers of elementary particle numbers and the observed particle families should correspond to various boundary topologies.

With the advent of zero energy ontology (ZEO) this picture has changed somewhat.

1. The wormhole throats identified as light-like 3-surfaces at with the induced metric of the space-time surface changes its signature from Minkowskian to Euclidian correspond to the light-like orbits of partonic 2-surfaces. One cannot of course exclude the possibility that also boundary components allow to satisfy boundary conditions without assuming vacuum extremal property of nearby space-time surface.

The intersections of the wormhole throats with the light-like boundaries of causal diamonds (CDs) identified as intersections of future and past directed light cones ($CD \times CP_2$ is actually in question but I will speak about CDs) define special partonic 2-surfaces and the conformal moduli of these partonic 2-surfaces appear in the elementary particle vacuum functionals [K36] naturally. A modification of the original simple picture came from the proposed identification of physical particles as bound states of two wormhole contacts connected by tubes carrying monopole fluxes.

2. For generalized scattering diagrams stringy trouser vertices are replaced with vertices at which the ends of light-like wormhole throats meet. This vertex is the analog of 3-vertex for Feynman diagrams in particle physics lengths scales and for the biological replication (DNA and even cell) in macroscopic length scales.

In this picture the interpretation of the analog of trouser vertex is in terms of propagation of same particle along two different paths. This interpretation is mathematically natural since vertices correspond to 2-manifolds rather than singular 2-manifolds, which are just splitting to two disjoint components. Second complication comes from the weak form of electric-magnetic duality forcing to identify physical particles as weak strings with magnetic monopoles at their ends and one should understand also the possible complications caused by this generalization.

These modifications force to consider several options concerning the identification of light fermions and bosons and one can end up with a unique identification only by making some assumptions. Masslessness of all wormhole throats - also those appearing in internal lines - and dynamical SU(3) symmetry for particle generations are attractive general enough assumptions of this kind. Bosons and their possible spartners would correspond to wormhole contacts with fermion and anti-fermion at the throats of the contact. The expectation was the free fermions and their possible spartners correspond to CP_2 type vacuum extremals with single wormhole throat. It however turned however that dynamical SU(3) symmetry forces to identify massive (and possibly topologically condensed) fermions as pairs of (g, g) type wormhole contacts. The existence of higher boson families would mean breaking of quark and lepton universality and there are indications for this kind of anomaly [K81].

The notion of elementary particle vacuum functional

Obviously one must know something about the dependence of the elementary particle state functionals on the geometric properties of the boundary component and in the sequel an attempt to construct what might be called elementary particle vacuum functionals (EPVFs), is made. The basic assumptions underlying the construction are the following ones [K36].

- 1. EPVFs depend on the geometric properties of the two-surface X^2 representing elementary particle.
- 2. EPVFs possess extended Diff invariance: all 2-surfaces on the orbit of the 2-surface X^2 correspond to the same value of the vacuum functional. This condition is satisfied if vacuum functionals have as their argument, not X^2 as such, but some 2- surface Y^2 belonging to the unique orbit of X^2 (determined by the principle selecting PE as a generalized Bohr orbit [K65, K14, K21]) and determined in general coordinate invariant manner.
- 3. ZEO allows to select uniquely the partonic 2-surface as the intersection of the wormhole throat at which the signature of the induced 4-metric changes with either the upper or lower boundary of $CD \times CP_2$. This is essential since otherwise one one could not specify the vacuum functional uniquely.
- 4. Vacuum functionals possess conformal invariance and therefore for a given genus depend on a finite number of variables specifying the conformal equivalence class of Y^2 .
- 5. Vacuum functionals satisfy the cluster decomposition property: when the surface Y^2 degenerates to a union of two disjoint surfaces (particle decay in string model inspired picture), vacuum functional decomposes into a product of the vacuum functionals associated with disjoint surfaces.
- 6. EPVFs are stable against the decay $g \to g_1 + g_2$ and one particle decay $g \to g 1$. This process corresponds to genuine particle decay only for stringy diagrams. For generalized scattering diagrams the interpretation is in terms of propagation along two different paths simultaneously.

In [K36] the construction of EPVFs is described in detail. This requires some basic concepts related to the description of the space of the conformal equivalence classes of Riemann surfaces and the concept of hyper-ellipticity. Since theta functions will play a central role in the construction of the vacuum functionals, also their basic properties are needed. Also possible explanations for the experimental absence of the higher fermion families are considered. Concerning p-adic mass calculations, the key question is how to construct p-adic variants of EPVFs.

5.3.3 p-Adic mass calculations

p-Adic thermodynamics

Consider first the basic ideas of p-adic thermodynamics.

1. p-Adic valued mass squared is identified as as thermal mass in p-adic thermodynamics. Boltzmann weights exp(-E/T) do not make sense if one just replaces exponent function with the p-adic variant of its Taylor series. The reason is that exp(x) has p-adic norm equal to 1 for all acceptable values of the argument x (having p-adic norm smaller than one) so that partition function does not have the usual exponential convergence property. Nothing however prevents from consider Boltzmann weights as powers p^n making sense for integer values of n. Here the p-adic norm approaches zero for $n \to +\infty$: thus the correspondences $e^{-E/T} \leftrightarrow p^{E/T_p}$.

The values of E/T_p must be quantized to integers. This is guaranteed if E is integer valued in suitable unit of energy and $1/T_p$ has integer valued spectrum using same unit for T_p . Super-conformal invariance guarantees integer valued spectrum of E, which in the recent case corresponds to mass squared. These number theoretical conditions are very powerful and lead to the quantization of also thermal mass squared for given p-adic prime p.

- 2. The p-adic mass squared is mapped to real number by canonical identification $I : \sum x_n p^n \to \sum x_n p^{-n}$ or its variant for rationals. Canonical identification is continuous and maps powers of p^n to their inverses. One modification of canonical identification maps rationals m/n in their representation in which m and n have no common divisors to I(m)/I(n). The predictions of calculations depend in some cases on which variant one uses but rational option looks the most reasonable choice.
- 3. p-Adic length scale hypothesis states that preferred p-adic primes correspond to powers of 2: $p \simeq 2^k$, but smaller than 2^k . The values of k form with $p = 2^k 1$ is prime Mersenne prime are especially favored. The nearer the prime p to 2^k , the more favored p is physically. One justification for the hypothesis is that preferred primes have been selected by an evolutionary process.
- 4. It turns out that p-adic temperature is $T_p = 1$ for fermions. For gauge bosons $T_p \leq 1/2$ seems to be necessary assumption for gauge bosons implying that the contribution to mass squared is very small so that super-symplectic contribution assignable to the wormhole magnetic flux tube dominates for weak bosons. For canonical identification $m/n \to I(m)/I(n)$ second order contribution to fermionic mass squared is very small.
- 5. The large values of p-adic prime p guarantee that the p-adic thermodynamics converves extremely rapidly. For $m/n \to I(m)/I(n)$ already the second order contribution is extremely small since the expansion for the real mass squared is in terms of 1/p and for electron with $p = M_{127}$ one has $p \sim 10^{38}$. Hence the calculations are essentially exact and errors are those of the model. It is quite possible that calculations could be done exactly using exact expressions for the super-symplectic partition functions generalized to p-adic context. The success of the p-adic mass calculations is especially remarkable because p-adic length scale hypothesis $p \simeq 2^k$ predicts exponential sensitivity of the particle mass scale on k.

Symmetries

The number theoretical existence of p-adic thermodynamics requires powerful symmetries to guarantee integer valued spectrum for the thermalized contribution to the mass squared.

1. Super-conformal symmetry with integer valued conformal weights for Virasoro scaling generator L_0 is essential because it predicts in string models that mass squared is apart from ground state contribution integer valued in suitable units. In TGD framework fermionic string world sheets are characterized by super-conformal symmetry. This gives the p-adic thermodynamics assumed in the calculations. One could however assign Super Virasoro algebra also to super-symplectic algebra having its analog as sub-algebra with positive integer conformal weights. Same applies to the extended conformal algebra of light-cone boundary. 2. TGD however predicts also generalization of conformal symmetry associated with light-cone boundary involving ordinary complex conformal weights and the conformal weight associated with the light-like radial coordinate. For the latter conformal weights for the generators of supersymmetry might be given by $h = -s_n/2$. s_n zero of zeta or pole h = -s = -1 of zeta.

Also super-symplectic symmetries would have similar radial spectrum of conformal weights. Conformal confinement requiring that the conformal weights of states are real implies that the spectrum of conformal weights for physical states consists of non-negative integers as for ordinary superconformal invariance.

It is not clear whether thermalization occurs in these degrees of freedom except perhaps for trivial conformal weights. These degrees of freedom need not therefore contribute to thermal masses of leptons and quarks but would give dominating contribution to hadron masses and weak boson masses. The negative conformal weights predicted by h = -s/2 hypothesis predicts that ground state weight is negative for super-symplectic representations and must be compensated for massless states.

The assumption that ground state conformal weight is negative and thus tachyonic is essential in case of p-adic mass calculations [K74], and only for massless particles (graviton, photon, gluons) it vanishes or is of order O(1/p). This could be achieved if the ground state of super-symplectic representation has h = 0.

3. Modular invariance [K36] assignable to partonic 2-surfaces is a further assumption similar to that made made in string models. This invariance means that for a given genus the dynamical degrees of freedom of the partonic 2-surface correspond to finite-dimensional space of Teichmueller parameters. For genus g = 0 this space is trivial.

Also modular invariance for string world sheets can be considered. By SH the information needed in mass calculations should be assignable to partonic 2-surfaces: the assumption is that one can assign this information to single partonic 2-surface. Stringy contribution would be seen only in scattering amplitudes.

This might be true only effectively: the recent view about elementary particles is that they are pairs of wormhole contacts connected by flux tubes defining a closed monopole flux and wormhole throats of contact have same genus for light states. Furthermore the quantum numbers of particle are associated with single throat for fermions and with opposite throats of single contact for bosons. The second wormhole contact would carry neutralizing weak charges to realize the finite range of weak interactions as "weak confinement".

The number of genera is infinite and one must understand why only three quark and lepton generations are observed. An attractive explanation is in terms of symmetry. For the three lowest genera the partonic 2-surfaces are always hyper-elliptic and have thus global conformal Z_2 symmetry. For higher genera this is not true always and EPVFs constructed from the assumption of modular invariance vanish for the hyper-elliptic surfaces. This suggests that the higher genera are very massive or can be interpreted as many-particle states of handles, which are not bound states but have continuous mass squared.

Contributions to mass squared

There are several contributions to the p-adic thermal mass squared come from the degrees of freedom, which are thermalized.

Super-conformal degrees of freedom associated with string world sheets are certainly thermalized. p-Adic mass calculations strongly suggest that the number of super-conformal tensor factors is N = 5 but also N = 4 and N = 6 can be considered marginally.

I have considered several identifications of tensor factors and not found a compelling alternative. If one assumes that super-symplectic degrees of freedom do not contribute to the thermal mass, string world sheets should explain masses of elementary fermions. Here charged lepton masses are the test bench. One other hand, if super-symplectic degrees of freedom contribute one obtains additional tensor factor assignable to h = -s/2, s trivial zero of zeta). Only one tensor factor emerges since Hamiltonians correspond to the products of functions of the coordinates of light-cone boundary and CP_2).

- 1. $SU(2)_L \times U(1)$ gives 2 tensor factors. SU(3) gives 1 tensor factor. The two transversal degrees of freedom for string world sheet suggest 2 degrees of freedom corresponding to Abelian group E^2 . Rotations however transforms these degrees to each other so that 1 tensor factor should emerge. This gives 4 tensor factors. Could it correspond to the degrees of freedom parallel to string at its end assignable to wormhole throat? Could normal vibrations of partonic 2surface? This would N = 5 tensor factors. Another possibility is that the fifth tensor factor comes from super-symplectic Super-Virasoro algebra defined by trivial conformal weights.
- 2. Super-symplectic contributions need not be present for ordinary elementary fermions. For weak bosons they could give string tension assignable to the magnetic flux tube connecting the wormhole contacts. It is not clear whether this contribution is thermalized. This contribution might be present only for the phases with $h_{eff} = n \times h$. This contribution would dominate in hadron masses.
- 3. Color degrees of freedom contribute to the ground state mass squared since ground state corresponds to an imbedding space spinor mode massless in 8-D sense. The mass squared contribution corresponds to an eigenvalue of CP_2 spinor d'Alembertian. Its eigenvalues correspond to color multiplets and only the covariantly constant right handed neutrino is color singlet. For the other modes the color representation is non-trivial and depends on weak quantum numbers of the fermion. The construction of the massless state from a tachyonic ground state with conformal weight $h_{vac} = -3$ must involve colored super-Kac Moody generators compensating for the anomalous color charge so that one obtains color single for leptons and color triplet for quarks as massless state.
- 4. Modular degrees of freedom give a contribution depending on the genus g of the partonic 2surface. This contribution is estimated by considering p-adic variants of elementary particle vacuum functionals Ω_{vac} [K74] expressible as products of theta functions with the structure of partition function. Theta functions are expressible as sums of exponent functions exp(X)with X defined as a contraction of the matrix Ω_{ij} defined by Teichmueller parameters between integer valued vectors.

In ZEO the interpretation of Ω_{vac} is as a complex square root of partition functional (quantum theory as complex square root of thermodynamics in ZEO). The integral of $|\Omega|^2$ over allowed moduli has interpretation as partition function. The exponential $exp(Re(X)) = p^{Re(X)/log(p)}$ has interpretation as an exponential of "Hamiltonian" defined by the vacuum conformal weight defined by moduli. T = log(p) is identified as p-adic temperature as in ordinary p-adic thermodynamics.

NTU requires that the integration over the moduli parameters reduces to a sum over number theoretically universal moduli parameters. The exponents exp(X) must exist p-adically. PE property alone could guarantee this. The exponentials appearing in theta functions should reduce to products $p^k p^{iy} = exp(k/log(p))p^{iy}$ with k is integer and p^{iy} a root of unity. The vacuum expectation value of Re(X) contributing to the mass squared is obtained from the standard formula as logarithmic temperature derivative of the "integral" $\int |\Omega_{vac}|^2$. The formula is same as for the Super-Virasoro contributions apart from the integration reducing to a sum.

The considerations of the section 5.4.2 [L39] suggest that for given p-adic prime p the exponent k+iy corresponds to a linear combinations of poles of fermionic zeta $z_F(s) = \zeta(s)/\zeta(2s)$ in the class C(p) with non-negative integer coefficients. This class corresponds essentially to the conformal weights of a fractal sub-algebra of super-symplectic algebra. It could give rise also to the complex values of action so that Riemann zeta would define the core of TGD.

The general dependence of the contribution of genus g to mass squared on g follows from the functional form of EPVF as a product theta functions serving as building brick partition functions apart from overall multiplicative constant and gives a nice agreement with the observed charged lepton mass ratios. The basic feature of the formula is exponential dependence on g.

5. The super-symplectic stringy contribution assignable to the magnetic flux tube dominates for weak bosons and is analogous to the stringy contribution to the hadron masses. p-Adic mass calculations leave open several questions. What is the precise origin of preferred p-adic primes and of p-adic length scale hypothesis? How to understand the preferred number N = 5 of Super-Kac-Moody tensor factors? How to calculate the contribution of super-symplectic degrees of freedom - are they thermalized? Why only 3 lowest genera are light and what are the masses of the predicted bosonic higher genera implying breaking of fermion universality.

5.3.4 p-Adic length scale hypothesis

p-Adic length scale hypothesis [K3, K87] has served as a basic hypothesis of p-adic TGD for several years. This hypothesis states that the scales $L_p = \sqrt{pl}$, $l = 1.376 \cdot 10^4 \sqrt{G}$ are fundamental length scale at p-adic condensate level p. The original interpretation of the hypothesis was following:

- 1. Above the length scale L_p p-adicity sets on and effective course grained space-time or imbedding space topology is p-adic rather than ordinary real topology. Imbedding space topology seems to be more appropriate identification.
- 2. The length scale L_p serves as a p-adic length scale cutoff for the quantum field theory description of particles. This means that space-time begins to look like Minkowski space so that the QFT $M^4 \rightarrow CP_2$ becomes a realistic approximation. Below this length scale string like objects and other particle like 3-surfaces are important.
- 3. It is un-natural to assume that just single p-adic field would be chosen from the infinite number of possibilities. Rather, there is an infinite number of cutoff length scales. To each prime p there corresponds a cutoff length scale L_p above which p-adic quantum field theory $M^4 \rightarrow CP_2$ makes sense and one has a hierarchy of p-adic QFTs. These different p-adic field theories correspond to different hierarchically levels possibly present in the topological condensate. Hierarchical ordering $< p_1 < p_2 < ...$ means that only the surface $p_1 < p_2$ can condense on the surface p_2 . The condensed surface can in practice be regarded as a point like particle at level p_2 described by the p-adic conformal field theory below length scale L_{p_2} .

The recent view inspired by adelic physics is that preferred p-adic primes correspond to so called ramified primes for the algebraic extension of rationals defining the adele [K142]. Weak form of Negentropy Maximization Principle (WNMP) [K80] in turn allows to conclude that the length scales corresponding to powers of primes are preferred. Therefore p-adic length scale hypothesis generalizes. There is evidence for 3-adic time scales in biology [I97, I98] and 3-adic time scales can be also assigned with Pythagorean scale in geometric theory of harmony [K102] [L32].

5.3.5 Mersenne primes and Gaussian Mersennes are special

Mersenne primes and their complex counterparts Gaussian Mersennes pop up in p-adic mass calculations and both elementary particle physics, biology [K99], and astrophysics and cosmology [K77] provide support for them.

Mersenne primes

One can also consider the milder requirement that the exponent $\lambda = 2^{\epsilon L_0}$ represents trivial scaling represented by unit in good approximation for some p-adic topology. Not surprisingly, this is the case for $L_0 = mp^k$ since by Fermat's theorem $a^p \mod p = 1$ for any integer a, in particular a = 2. This is also the case for $L_0 = mk$ such that $2^k \mod p = 1$ for p prime. This occurs if $2^k - 1$ is Mersenne prime: in this case one has $2^{L_0} = 1 \mod p$ so that the sizes of the fractal sub-algebras are exponentially larger than the sizes of $L_0 \propto p^n$ algebras. Note that all scalings a^{L_0} are near to unity for $L_0 = p^n$ whereas now only a = 2 gives scalings near unity for Mersenne primes. Perhaps this extended fractality provides the fundamental explanation for the special importance of Mersenne primes.

In this case integrated scalings 2^{L_0} leave the states almost invariant so that even a stronger form of the breaking of the exact conformal invariance would be in question in the super-symplectic case. The representation would be defined by the generators for which conformal weights are odd multiples of n $(M_n = 2^n - 1)$ and L_{-kn} , k > 0 would generate zero norm states only in order $O(1/M_n)$. Especially interesting is the hierarchy of primes defined by the so called Combinatorial Hierarchy resulting from TGD based model for abstraction process. The primes are given by $2, 3, 7 = 2^3 - 1, 127 = 2^7 - 1, 2^{127} - 1, \ldots$ $L_0 = n \times 127$ would correspond to M_{127} -adicity crucial for the memetic code.

Gaussian Mersennes are also special

If one allows also Gaussian primes then the notion of Mersenne prime generalizes: Gaussian Mersennes are of form $(1 \pm i)^n - 1$. In this case one could replace the scaling operations by scaling combined with a twist of $\pi/4$ around some symmetry axis: $1 + i = \sqrt{2}exp(i\pi/4)$ and generalized p-adic fractality would mean that for certain values of n the exponentiated operation consisting of n basic operations would be very near to unity.

- 1. The integers k associated with the lowest Gaussian Mersennes are following: 2,3,5,7,11, 19,29,47,73,79,113. k = 113 corresponds to the p-adic length scale associated with the atomic nucleus and muon. Thus all known charged leptons, rather than only e and τ , as well as nuclear physics length scale, correspond to Mersenne primes in the generalized sense.
- 2. The primes k = 151, 157, 163, 167 define perhaps the most fundamental biological length scales: k = 151 corresponds to the thickness of the cell membrane of about ten nanometers and k = 167 to cell size about 2.56 μm . This observation also suggests that cellular organisms have evolved to their present form through four basic evolutionary stages. This also encourages to think that $\sqrt{2}exp(i\pi/4)$ operation giving rise to logarithmic spirals abundant in living matter is fundamental dynamical symmetry in bio-matter.

Logarithmic spiral provides the simplest model for biological growth as a repetition of the basic operation $\sqrt{2}exp(i\pi/4)$. The naive interpretation would be that growth processes consist of k = 151, 157, 163, 167 steps involving scaling by $\sqrt{2}$. This however requires the strange looking assumption that growth starts from a structure of size of order CP_2 length. Perhaps this exotic growth process is associated with pair of MEs or magnetic flux tubes of opposite time orientation and energy emergenging CP_2 sized region in a mini big bang type process and that the resulting structure serves as a template for the biological growth.

3. k = 239, 241, 283, 353, 367, 379, 457 associated with the next Gaussian Mersennes define astronomical length scales. k = 239 and k = 241 correspond to the p-adic time scales .55 ms and 1.1 ms: basic time scales associated with nerve pulse transmission are in question. k = 283 corresponds to the time scale of 38.6 min. An interesting question is whether this period could define a fundamental biological rhythm. The length scale L(353) corresponds to about 2.6×10^6 light years, roughly the size scale of galaxies. The length scale $L(367) \simeq \times 3.3 \times 10^8$ light years is of same order of magnitude as the size scale of the large voids containing galaxies on their boundaries (note the analogy with cells). $T(379) \simeq 2.1 \times 10^{10}$ years corresponds to the lower bound for the order of the age of the Universe. $T(457) \sim 10^{22}$ years defines a completely superastronomical time and length scale.

5.3.6 Questions

The proposed picture leaves open several questions.

- 1. Could the descriptions by both real and p-adic thermodynamics be possible? Could they be equivalent (possibly in finite measurement resolution) as is suggested by NTU? The consistency of these descriptions would imply temperature quantization and p-adic length scale hypothesis not possible in purely real context.
- 2. What could the extension of conformal symmetry to supersymplectic symmetry mean? One possible view is that super-symplectic symmetries correspond to dark degrees of freedom and that only the super-symplectic ground states with negative conformal weights affect the p-adic thermodynamics, which applies only to fermionic degrees of freedom at string world sheets. Super-symplectic degrees of freedom would give the dominant contribution to hadron masses and could contribute also to weak gauge boson masses. N = 5 for the needed number

of tensor factors is however a strong constraint and perhaps most naturally obtained when also the super-symplectic Virasoro associated with the trivial zeros of zeta is thermalized.

- 3. What happens in dark sectors. Preferred extremal property is proposed to mean that the states are annihilated by super-symplectic sub-algebra isomorphic to the original algebra and its commutator with the entire algebra. The conjecture is that this gives rise to Kac-Moody algebras as dynamical symmetries maybe ADE type algebras, whose Dynkin diagrams characterize the inclusion of HFFs. Does this give an additional tensor factor to super-Virasoro algebra?
- 4. Superconformal symmetry true in the sense that Super Virasoro conditions hold true. Partition function however depends on mass squared only rather than the entire scaling generator L_0 as thought erratically in the first formulation of p-adic calculation. This does not mean breaking of conformal invariance. Super Virasoro conditions hold true although partition function is for the vibrational part of L_0 determining the mass squared spectrum.

5.4 p-Adicization and adelic physics

This section is devoted to the challenges related to p-adicization and adelization of physics in which the correspondence between real and p-adic numbers via canonical identification serves as the basic building brick. Also the problems associated with p-adic variants of integral, Fourier analysis, Hilbert space, and Riemann geometry should be solved in a way respecting fundamental symmetries and their p-adic variants must be met. The notion of number theoretical universality (NTU) plays a key role here. One should also answer to questions about the origin of preferred primes and p-adic length scale hypothesis.

5.4.1 Challenges

The basic challenges encountered are construction of the p-adic variants of real number based physics, understanding their relationship to real physics, and the fusion of various physics to single coherent whole.

The p-adicization of real physics is not just a straightforward formal generalization of scattering amplitudes of existing theories but requires a deeper understanding of the physics involved. The interpretation of p-adic physics as correlate for cognition and imagination is an important guideline and will be discussed l in more detail in separate section.

Definite integral and Fourier analysis are basic elements of standard physics and their generalization to the p-adic context defines a highly non-trivial challenge. Also the p-adic variants of Riemann geometry and Hilbert space are suggestive. There are however problems.

1. There are problems associated with p-adic definite integral. Riemann sum does not make sense since it approaches zero if the p-adic norm of discretization unit approaches zero. The problems are basically due to the absence of well-orderedness essential for the definition of definite integral and differential forms and their integrals.

Residue integration might make sense in finite angle resolution. For algebraic extension containing $e^{i\pi/n}$ the number theoretically universal approximation $i\pi = n(e^{i\pi/n} - 1)$ could be used. In twistor approach integrations reduce to multiple residue integrations and since twistor approach generalizes in TGD framework, this approach to integration is very attractive.

Positivity is a central notion in twistor Grassmannian approach [B12]. Since canonical identification maps p-adic numbers to non-negative real numbers, there is a strong temptation to think that positivity relates to NTU [L41].

2. There are problems with Fourier analysis. The naive generalization of trigonometric functions by replacing e^{ix} with its p-adic counterpart is not physical. Same applies to e^x . Algebraic extensions are needed to get roots of unity ad e as counterparts of the phases and discretization is necessary and has interpretation in terms of finite resolution for angle/phase and its hyperbolic counterpart. 3. The notion of Hilbert space is problematic. The naive generalization of Hilbert space norm square $|x|^2 = \sum x_n \overline{x}_n$ for state $(x_1, x_2, ...)$ can vanish p-adically. Also here NTU could help. State would contain as coefficients only roots of e and unity and only the overall factor could be p-adic number. Coefficients could be restricted to the algebraic numbers generating the algebraic extension of rational numbers and would not contain powers of p or even ordinary p-adic numbers expect in the overall normalization factor.

Second challenge relates to the relationship between real and p-adic physics. Canonical identification (CI) $\sum x_n p^n \to \sum x_n p^{-n}$ or some of its variants should play an important role. CI is expected to map the invariants appearing in scattering amplitudes to their real counterparts.

- 1. Real and p-adic variants of space-time surfaces should exist and relate to each other somehow. Is this relationship local and involve CI at space-time level or imbedding space level? Or is it only a global and non-local assignment of preferred real extremals to their p-adic counterparts? Or is between these extreme options and involves algebraic discretization of the space-time surface weakening the strong form of SH as already proposed? How do real and p-adic imbedding spaces relate to each other and can this relationship induce local correspondence between preferred extremals (PEs) [K14, K21, K19]?
- 2. NTU in some sense is a highly suggestive approach to these questions and would suggest that canonical identification applies to isometry invariants whereas angles and hyperbolic angles, or rather the corresponding "phases" belonging to an extension of p-adics containing roots of *e* and roots of unity are mapped to themselves. Note that the roots of *e* define extensions of rationals, which induce finite dimensional algebraic extensions of p-adic numbers. This would make possible to define imbedding space in accordance with NTU. Also the Hilbert space could be defined by requiring that its points correspond to number theoretically universal angles expressible in terms of roots of unity.
- 3. What about real and p-adic variants of WCW? Are they needed at all? Or could their existence be used as a powerful constraint on real physics? The representability of WCW as a union of infinite-dimensional symmetric spaces labelled by zero modes suggests that the same description applies at the level of WCW and imbedding space.

One cannot circumvent the question about how to generalize functional integral from real WCW to p-adic WCWs. In particular, what is the p-adic variant of the action defining the dynamics of space-time surfaces. In the case of exponent of action the p-adic variant could be defined by assuming algebraic universality: again the roots of e and of unity would be in central role. Also the Kähler structure of WCW implying that Gaussian and metric determinants cancel each other in functional integral, would be absolutely crucial.

One must remember that the exponents of action for scattering amplitudes for the stationary phase extremal cancel from the path integral representation of scattering amplitudes. Also now this mechanism would allow to get rid of the poorly defined exponent for single minimum. If there is sum over scattering amplitudes assignable to different maxima, normalization sould give ratios of these exponents for different extrema/maxima and only these ratios should belong to the extension of rationals.

The zero modes of WCW metric are invariants of supersymplectic group so that canonical identification could relate their real and p-adic variants. Zero modes could break NTU and would be behind p-adic thermodynamics and dependence of mass scale on p-adic prime.

The third challenge relates to the fusion of p-adic physics and real physics to a larger structure. Here a generalization of number concept obtained by glueing reals and various p-adics together along an extension of rational numbers inducing the extensions of p-adic numbers is highly suggestive. Adeles associated with the extension of rationals are highly attractive and closely related notion. Real and various p-adic physics would be correlates for sensory and cognitive aspects of the same universal physics rather than separate physics in this framework. One important implication of this view is that real entropy and p-adic negentropies characterize the same entanglement with coefficients in an extension of rationals.

NTU for hyperbolic and ordinary phases is definetely the central idea. How the invariance of angles under conformal transformations does relate to this? Could one perhaps define a discretized version of conformal symmetry preserving the phases defined by the angles between vectors assignable with the tangent spaces of discretized geometric structures and thus respecting NTU? Of should one apply conformal symmetry at Lie algebra level only?

5.4.2 NTU and the correspondence between real and p-adic physics

p-Adic real correspondence is certainly the basic problem of p-adicization and adelization. One can make several general questions about p-adic real correspondence and canonical identification inspired by p-adic mass calculations.

How generally p-adic real correspondence does apply? Could canonical identification for group invariants combined with direct identification of ordinary and hyperbolic phases identified as roots of unity and *e* apply at WCW and imbedding space level having maximally symmetric geometries? Could this make sense even at space-time level as a correspondence induced from imbedding space level [L56]? Does canonical identification apply locally for the discretizations of space-time surface or only globally for the parameters characterizing PEs (string world sheets and partonic 2-surfaces by SH), which are general coordinate invariant and Poincare invariant quantities?

The following vision seems to be the most feasible one found hitherto.

- 1. Preservation of symmetries and continuity compete. Lorenz transformations do not commute with canonical identification. This suggests that canonical identification applies only to Lorentz invariants formed from quantum numbers. This is enough in the case of scattering amplitudes. Canonical identification applies only to isometry invariants at the level of WCW and the phases/exponents of ordinary/hyperbolic angles correspond to numbers in the algebraic extension common to extensions of rationals and various p-adics.
- 2. Canonical identification applies at the level of momentum space and maps p-adic Lorentz invariants of scattering amplitudes to their real counterparts. Phases of angles and their hyperbolic counterparts should correspond to parameters defining extension and should be mapped as such to their p-adic counterparts.
- 3. The constraints coming from GCI and symmetries do not allow local correspondence but allow to consider its discretized version at space-time leve induced by the correspondence at the level of imbedding space.

This requires the restriction of isometries and other symmetries to algebraic subgroups defined by the extension of rationals. This would imply reduction of symmetry due to finite cognitive/measurement resolution and should be acceptable. If one wants to realize the ideas about imagination, discretization must be applied also for the space-time interior meaning partial breaking of SH and giving rise to dark matter degrees freedom in TGD sense. SH could apply in real sector for realizable imaginations only. Note that the number of algebraic points of space-time surface is expected to be relatively small.

The correspondence must be considered at the level of imbedding space, space-time, and WCW.

- 1. At the level of imbedding space p-adic–real correspondence is induced by points in extension of rationals and is totally discontinuous. This requires that space-time dimension is smaller than imbedding space dimension.
- 2. At space-time level the correspondence involves field equations derivable from a local variational principle make sense also p-adically although the action itself is ill-defined as 4-D integral. The notion of p-adic PE makes sense by strong form of holography applied to 2surfaces in the intersection. p-Adically however only the vanishing of Noether currents for a sub-algebra of the super-symplectic algebra might make sense. This condition is stronger than the vanishing of Noether charges defined by 3-D integrals.
- 3. Correspondence at the level of WCW can make sense and reduces to that for string world sheets and partonic 2-surfaces by SH. Real and p-adic 4-surfaces would be obtained by algebraic continuation as PEs from 2-surfaces by assuming that the space-time surface contains
subset of points of imbedding space belonging to the extension of rationals [L56]. p-Adic pseudo constants make p-adic continuation easy. Real continuation need not exist always. p-Adic WCW would be considerably larger than real WCW and make possible a predictive quantum theory of imagination and cognition.

What I have called intersection of realities and p-adicities can be identified as the set of 2-surfaces plus algebraic discretization of space-time interior. Also the values of induced spinor fields at the points of discretization must be given. The parameters characterizing the extremals (say coefficients of polynomials) - WCW coordinates - would be in extension of rationals inducing a finite-D extension of p-adic number fields.

The hierarchy of algebraic extensions induces an evolutionary hierarchy of adeles. The interpretation could be as a mathematical correlate for cosmic evolution realized at the level of the core of WCW defined by the intersection? 2-surfaces could be called space-time genes.

4. Also the p-adic variant Kähler action or at least the exponent of Kähler action defining vacuum functional should be obtainable by algebraic continuation. The weakest condition states that the ratios of action exponents for the maxima of Kähler function to the sum of action exponents for maxima belong to the extension. Without this condition the hopes of satisfying NTU seem rather meager.

5.4.3 NTU at space-time level

What about NTU at space-time level? NTU requires a correspondence between real and p-adic numbers and the details of this corresponds have been a long standing problem.

1. The recent view about the correspondence between real PEs to their p-adic counterparts does not demand discrete local correspondence assumed in the earlier proposal [K145]. The most abstract approach would give up the local correspondence at space-time level altogether, and restrict the preferred coordinates of WCW (having maximal group of isometries) to numbers in the extension of rationals considered. WCW would be discretized.

Intuitively a more realistic view is a correspondence at space-time level in the sense that real and p-adic space-time sheets intersect at points belonging to the extension of rationals and defining "cognitive representations". Only some p-adic space-time surfaces would have real counterpart.

- 2. The strongest form of NTU would require that the allowed points of imbedding space belonging an extension of rationals are mapped as such to corresponding extensions of p-adic number fields (no canonical identification). At imbedding space level this correspondence would be extremely discontinuous. The "spines" of space-time surfaces would however contain only a subset of points of extension, and a natural resolution length scale could emerge and prevent the fluctuation. This could be also seen as a reason for why space-times surfaces must be 4-D. The fact that the curve $x^n + y^n = z^n$ has no rational points for n > 2, raises the hope that the resolution scale could emerge spontaneously.
- 3. The notion of monadic geometry discussed in detail in [L56] would realize this idea. Define first a number theoretic discretization of imbedding space in terms of points, whose coordinates in group theoretically preferred coordinate system belong to the extension of rationals considered. One can say that these algebraic points are in the intersection of reality and various p-adicities. Overlapping open sets assigned with this discretization define in the real sector a covering by open sets. In p-adic sector compact-open-topology allows to assign with each point 8th Cartesian power of algebraic extension of p-adic numbers. These compact open sets define analogs for the monads of Leibniz and p-adic variants of field equations make sense inside them.

The monadic manifold structure of H is induced to space-time surfaces containing discrete subset of points in the algebraic discretization with field equations defining a continuation to space-time surface in given number field, and unique only in finite measurement resolution. This approach would resolve the tension between continuity and symmetries in p-adic–real correspondence: isometry groups would be replaced by their sub-groups with parameters in extension of rationals considered and acting in the intersection of reality and p-adicities.

The Galois group of extension acts non-trivially on the "spines" of space-time surfaces. Hence the number theoretical symmetries act as physical symmetries and define the orbit of given space-time surface as a kind of covering space. The coverings assigned to the hierarchy of Planck constants would naturally correspond to Galois coverings and dark matter would represent number theoretical physics.

This would give rise to a kind of algebraic hierarchy of adelic 4-surfaces identifiable as evolutionary hierarchy: the higher the dimension of the extension, the higher the evolutionary level.

5.4.4 NTU and WCW

p-Adic-real correspondence at the level of WCW

It has not been obvious whether one should perform p-adicization and adelization at the level of WCW. Minimalist could argue that scattering amplitudes are all we want and that their padicization and adelization by algebraic continuation can be tolerated only if it can give powerful enough constraints on the amplitudes.

- 1. The anti-commutations for fermionic oscillator operators are number theoretically universal. Supersymmetry suggests that also WCW bosonic degrees of freedom satisfy NTU. This could mean that the coordinates of p-adic WCW consist of super-symplectic invariants mappable by canonical identification to their real counterparts plus phases and their hyperbolic counterparts expressible as genuinely algebraic numbers common to all number fields. This kind of coordinates are naturally assignable to symmetric spaces [L56].
- 2. Kähler structure should be mapped from p-adic to real sector and vice versa. Vacuum functional identified as exponent of action should be NTU. Algebraic continuation defined by SH involves p-adic pseudo constants. All p-adic continuations by SH should correspond to the same value of exponent of action obtained by algebraic continuation from its real value. The degeneracy associated with p-adic pseudo-constants would be analogous to gauge invariance imagination in TGD inspired theory of consciousness.
- 3. Ist it possible have NTU for WCW functional integration? Or is it enough to realize NTU for scattering amplitudes only. What seems clear that functional integral must reduce to a discrete sum. Physical intuition suggests a sum over maxima of Kähler function forming a subset of PEs representing stationary points. One cannot even exclude the possibility that the set of PEs is discrete and that one can sum over all of them.

Restriction to maximum/stationary phase approximation gives rise to sum over exponents multiplied with Gaussian determinants. The determinant of Kähler metric however cancels the Gaussian determinants, and one obtains only a sum over the exponents of action.

The breaking of strong NTU could happen: consider only p-adic mass calculations. This breaking is however associated with the parts of quantum states assignable to the boundaries of CD, not with the vacuum functional.

NTU for functional integral

Number theoretical vision relies on NTU. In fermionic sector NTU is necessary: one cannot speak about real and p-adic fermions as separate entities and fermionic anti-commutation relations are indeed number theoretically universal.

What about NTU in case of functional integral? There are two opposite views.

1. One can define p-adic variants of field equations without difficulties if preferred extremals are minimal surface extremals of Kähler action so that coupling constants do not appear in the solutions. If the extremal property is determined solely by the analyticity properties as it is for various conjectures, it makes sense independent of number field. Therefore there would be no need to continue the functional integral to p-adic sectors. This in accordance with the philosophy that thought cannot be put in scale. This would be also the option favored by pragmatist.

2. Consciousness theorist might argue that also cognition and imagination allow quantum description. The supersymmetry NTU should apply also to functional integral over WCW (more precisely, its sector defined by CD) involved with the definition of scattering amplitudes.

1. Key observations

The general vision involves some crucial observations.

- 1. Only the expressions for the scatterings amplitudes should should satisfy NTU. This does not require that the functional integral satisfies NTU.
- 2. Since the Gaussian and metric determinants cancel in WCW Kähler metric the contributions form maxima are proportional to action exponentials $exp(S_k)$ divided by the $\sum_k exp(S_k)$. Loops vanish by quantum criticality.
- 3. Scattering amplitudes can be defined as sums over the contributions from the maxima, which would have also stationary phase by the double extremal property made possible by the complex value of α_K . These contributions are normalized by the vacuum amplitude.

It is enough to require NTU for $X_i = exp(S_i) / \sum_k exp(S_k)$. This requires that $S_k - S_l$ has form $q_1 + q_2i\pi + q_3log(n)$. The condition brings in mind homology theory without boundary operation defined by the difference $S_k - S_l$. NTU for both S_k and $exp(S_k)$ would only values of general form $S_k = q_1 + q_2i\pi + q_3log(n)$ for S_k and this looks quite too strong a condition.

4. If it is possible to express the 4-D exponentials as single 2-D exponential associated with union of string world sheets, vacuum functional disappears completely from consideration! There is only a sum over discretization with the same effective action and one obtains purely combinatorial expression.

2. What does one mean with functional integral?

The definition of functional integral in WCW is one of the key technical problems of quantum TGD [K142]. NTU states that the integral should be defined simultaneously in all number fields in the intersection of real and p-adic worlds defined by string world sheets and partonic 2-surfaces with WCW coordinates in algebraic extension of rationals and allowing by strong holography continuation to 4-D space-time surface. NTU is powerful constraint and could help in this respect.

1. Path integral is not in question. Rather, the functional integral is analogous to Wiener integral and perhaps allows identification as a genuine integral in the real sector. In p-adic sectors algebraic continuation should give the integral and here number theoretical universality gives excellent hopes. The integral would have exactly the same form in real and p-adic sector and expressible solely in terms of algebraic numbers characterizing algebraic extension and finite roots of e and roots of unity $U_n = exp(i2\pi/n)$ in algebraic extension of p-adic numbers.

Since vacuum functional exp(S) is exponential of complex action S, the natural idea is that only rational powers e^q and roots of unity and phases $exp(i2\pi q)$ are involved and there is no dependence on p-adic prime p! This is true in the integer part of q is smaller than p so that one does not obtain e^{kp} , which is ordinary p-adic number and would spoil the number theoretic universality. This condition is not possible to satisfy for all values of p unless the value of Kähler function is smaller than 2. One might consider the possibility that the allow primes are above some minimum value.

The minimal solution to NTU conditions is that the ratios of action exponentials for maxima of Kähler function to the sum of these exponentials belong to the extension of rationals considered.

2. What does one mean with functional integral? TGD is expected to be an integrable in some sense. In integrable QFTs functional integral reduces to a sum over stationary points of the action: typically only single point contributes - at least in good approximation.

For real α_K and Λ vacuum functional decomposes to a product of exponents of real contribution from Euclidian regions ($\sqrt{g_4}$ real) and imaginary contribution Minkowskian regions ($\sqrt{g_4}$ imaginary). There would be no exchange of momentum between Minkowskian and Euclidian regions. For complex values of α_K [K54] situation changes and Kähler function as real part of action receives contributions from both Euclidian and Minkowskian regions. The imaginary part of action has interpretation as analog of Morse function and action as it appears in QFTs. Now saddle points must be considered.

PEs satisfy extremely strong conditions [K14, K19]. All classical Noether charges for a sub-algebra associated with super-symplectic algebra and isomorphic to the algebra itself vanish at both ends of CD. The conformal weights of this algebra are n > 0-ples of those for the entire algebra. What is fascinating that the condition that the preferred extremals are minimal surface extremals of Kähler action could solve these conditions and guarantee also NTU at the level of space-time surfaces. Supersymplectic boundary conditions at the ends of CD would however pose number theoretic conditions on the coupling parameters. In p-adic case the conditions should reduce to purely local conditions since p-adic charges are not well-defined as integrals.

3. In TGD framework one is constructing zero energy states rather calculating the matrix elements of S-matrix in terms of path integral. This gives certain liberties but a natural expectation is that functional integral as a formal tool at least is involved.

Could one *define* the functional integral as a discrete sum of contributions of standard form for the preferred extremals, which correspond to maxima in Euclidian regions and associated stationary phase points in Minkowskian regions? Could one assume that WCW spinor field is concentrated along single maximum/stationary point.

Quantum classical correspondence suggests that in Cartan algebra isometry charges are equal to the quantal charges for quantum states expressible in number theoretically universal manner in terms of fermionic oscillator operators or WCW gamma matrices? Even stronger condition would be that classical correlation functions are identical with quantal ones for allowed space-time surfaces in the quantum superposition. Could the reduction to a discrete sum be interpreted in terms of a finite measurement resolution?

4. In QFT Gaussian determinants produce problems because they are often poorly defined. In the recent case they could also spoil the NTU based on the exceptional properties of *e*. In the recent case however Gaussian determinant and metric determinant for Kähler metric cancel each other and this problem disappears. One could obtain just a sum over products of roots of *e* and roots of unity. Thus also Kähler structure seems to be crucial for the dream about NTU.

5.4.5 Breaking of NTU at the level of scattering amplitudes

NTU in strong sense could be broken at the level of scattering amplitudes. At space-time level the breaking does not look natural in the recent framework. Consider only p-adic mass calculations predicting that mass scale depends on p-adic prime. Also for the action strong form of NTU might fail for small p-adic primes since the value of the real part of action would be larger than than p. Should one allow this? What does one actually mean with NTU in the case of action?

Canonical identification is an important element of p-adic mass calculations and might also be needed to map p-adic variants of scattering amplitudes to their real counterparts. The breaking of NTU would take place, when the canonical real valued image of the p-adic scattering amplitude differs from the real scattering amplitude. The interpretation would be in terms of finite measurement resolution. By the finite measurement/cognitive resolution characterized by p one cannot detect the difference.

The simplest form of the canonical identification is $x = \sum_n x_n p^n \to \sum x_n p^{-n}$. Product xy and sum x + y do not in general map to product and sum in canonical identification. The

interpretation would be in terms of a finite measurement resolution: $(xy)_R = x_R y_R$ and $(x+y)_R = x_R + y_R$ only modulo finite measurement resolution. p-Adic scattering amplitudes are obtained by algebraic continuation from the intersection by replacing algebraic number valued parameters (such as momenta) by general p-adic numbers. The real images of these amplitudes under canonical identification are in general not identical with real scattering amplitudes the interpretation being in terms of a finite measurement resolution.

In p-adic thermodynamics NTU in the strong sense fails since thermal masses depend on p-adic mass scale. NTU can be broken by the fermionic matrix elements in the functional integral so that the real scattering amplitudes differ from the canonical images of the p-adic scattering amplitudes. For instance, the elementary particle vacuum functionals in the space of Teichmueller parameters for the partonic 2-surfaces and string world sheets should break NTU [K36].

5.4.6 NTU and the spectrum of Kähler coupling strength

During years I have made several attempts to understand coupling evolution in TGD framework. The most convincing proposal has emerged rather recently and relates the spectrum of $1/\alpha_K$ to that for the zeros of Riemann zeta [K54] and to the evolution of the electroweak U(1) couplings strength.

1. The first idea dates back to the discovery of WCW Kähler geometry defined by Kähler function defined by Kähler action (this happened around 1990) [K65]. The only free parameter of the theory is Kähler coupling strength α_K analogous to temperature parameter α_K postulated to be is analogous to critical temperature. Whether only single value or entire spectrum of of values α_K is possible, remained an open question.

About decade ago I realized that Kähler action is *complex* receiving a real contribution from space-time regions of Euclidian signature of metric and imaginary contribution from the Minkoswkian regions. Euclidian region would give Kähler function and Minkowskian regions analog of QFT action of path integral approach defining also Morse function. Zero energy ontology (ZEO) [K146] led to the interpretation of quantum TGD as complex square root of thermodynamics so that the vacuum functional as exponent of Kähler action could be identified as a complex square root of the ordinary partition function. Kähler function would correspond to the real contribution Kähler action from Euclidian space-time regions. This led to ask whether also Kähler coupling strength might be complex: in analogy with the complexification of gauge coupling strength in theories allowing magnetic monopoles. Complex α_K could allow to explain CP breaking. I proposed that instanton term also reducing to Chern-Simons term could be behind CP breaking.

The problem is that the dynamics in Minkowskian and Euclidian regions decouple completely and if Euclidian regions serve as space-time correlates for physical objects, there would be no exchanges of classical charges between physical objects. Should one conclude that α_K must be complex?

- 2. p-Adic mass calculations for 2 decades ago [K74] inspired the idea that length scale evolution is discretized so that the real version of p-adic coupling constant would have discrete set of values labelled by p-adic primes. The simple working hypothesis was that Kähler coupling strength is renormalization group (RG) invariant and only the weak and color coupling strengths depend on the p-adic length scale. The alternative ad hoc hypothesis considered was that gravitational constant is RG invariant. I made several number theoretically motivated ad hoc guesses about coupling constant evolution, in particular a guess for the formula for gravitational coupling in terms of Kähler coupling strength, action for CP_2 type vacuum extremal, p-adic length scale as dimensional quantity. Needless to say these attempts were premature and a hoc.
- 3. The vision about hierarchy of Planck constants $h_{eff} = n \times h$ and the connection $h_{eff} = h_{gr} = GMm/v_0$, where $v_0 < c = 1$ has dimensions of velocity [?] forced to consider very seriously the hypothesis that Kähler coupling strength has a spectrum of values in one-one correspondence with p-adic length scales. A separate coupling constant evolution associated with h_{eff} induced by $\alpha_K \propto 1/\hbar_{eff} \propto 1/n$ looks natural and was motivated by the idea that

Nature is theoretician friendly: when the situation becomes non-perturbative, Mother Nature comes in rescue and an h_{eff} increasing phase transition makes the situation perturbative again.

Quite recently the number theoretic interpretation of coupling constant evolution [K142] [L39] in terms of a hierarchy of algebraic extensions of rational numbers inducing those of p-adic number fields encouraged to think that $1/\alpha_K$ has spectrum labelled by primes and values of h_{eff} . Two coupling constant evolutions suggest themselves: they could be assigned to length scales and angles which are in p-adic sectors necessarily discretized and describable using only algebraic extensions involve roots of unity replacing angles with discrete phases.

- 4. Few years ago the relationship of TGD and GRT was finally understood [K137]. GRT spacetime is obtained as an approximation as the sheets of the many-sheeted space-time of TGD are replaced with single region of space-time. The gravitational and gauge potential of sheets add together so that linear superposition corresponds to set theoretic union geometrically. This forced to consider the possibility that gauge coupling evolution takes place only at the level of the QFT approximation and α_K has only single value. This is nice but if true, one does not have much to say about the evolution of gauge coupling strengths.
- 5. The analogy of Riemann zeta function with the partition function of complex square root of thermodynamics suggests that the zeros of zeta have interpretation as inverses of complex temperatures $s = 1/\beta$. Also $1/\alpha_K$ is analogous to temperature. This led to a radical idea to be discussed in detail in the sequel.

Could the spectrum of $1/\alpha_K$ reduce to that for the zeros of Riemann zeta or - more plausibly - to the spectrum of poles of fermionic zeta $\zeta_F(ks) = \zeta(ks)/\zeta(2ks)$ giving for k = 1/2 poles as zeros of zeta and as point s = 2? ζ_F is motivated by the fact that fermions are the only fundamental particles in TGD and by the fact that poles of the partition function are naturally associated with quantum criticality whereas the vanishing of ζ and varying sign allow no natural physical interpretation.

The poles of $\zeta_F(s/2)$ define the spectrum of $1/\alpha_K$ and correspond to zeros of $\zeta(s)$ and to the pole of $\zeta(s/2)$ at s = 2. The trivial poles for s = 2n, n = 1, 2, ... correspond naturally to the values of $1/\alpha_K$ for different values of $h_{eff} = n \times h$ with n even integer. Complex poles would correspond to ordinary QFT coupling constant evolution. The zeros of zeta in increasing order would correspond to p-adic primes in increasing order and UV limit to smallest value of poles at critical line. One can distinguish the pole s = 2 as extreme UV limit at which QFT approximation fails totally. CP_2 length scale indeed corresponds to GUT scale.

6. One can test this hypothesis. $1/\alpha_K$ corresponds to the electroweak U(1) coupling strength so that the identification $1/\alpha_K = 1/\alpha_{U(1)}$ makes sense. One also knows a lot about the evolutions of $1/\alpha_{U(1)}$ and of electromagnetic coupling strength $1/\alpha_{em} = 1/[\cos^2(\theta_W)\alpha_{U(1)}]$. What does this predict?

It turns out that at p-adic length scale k = 131 ($p \simeq 2^k$ by p-adic length scale hypothesis, which now can be understood number theoretically [K142]) fine structure constant is predicted with .7 per cent accuracy if Weinberg angle is assumed to have its value at atomic scale! It is difficult to believe that this could be a mere accident because also the prediction evolution of $\alpha_{U(1)}$ is correct qualitatively. Note however that for k = 127 labelling electron one can reproduce fine structure constant with Weinberg angle deviating about 10 per cent from the measured value of Weinberg angle. Both models will be considered.

7. What about the evolution of weak, color and gravitational coupling strengths? Quantum criticality suggests that the evolution of these couplings strengths is universal and independent of the details of the dynamics. Since one must be able to compare various evolutions and combine them together, the only possibility seems to be that the spectra of gauge coupling strengths are given by the poles of $\zeta_F(w)$ but with argument w = w(s) obtained by a global conformal transformation of upper half plane - that is Möbius transformation (see http://tinyurl.com/gwjs85b) with real coefficients (element of GL(2, R)) so that one as $\zeta_F((as + b)/(cs + d))$. Rather general arguments force it to be and element of GL(2, Q), GL(2, Z) or maybe even SL(2, Z) (ad - bc = 1) satisfying additional constraints. Since TGD

predicts several scaled variants of weak and color interactions, these copies could be perhaps parameterized by some elements of SL(2, Z) and by a scaling factor K.

Could one understand the general qualitative features of color and weak coupling contant evolutions from the properties of corresponding Möbius transformation? At the critical line there can be no poles or zeros but could asymptotic freedom be assigned with a pole of cs + dand color confinement with the zero of as + b at real axes? Pole makes sense only if Kähler action for the preferred extremal vanishes. Vanishing can occur and does so for massless extremals characterizing conformally invariant phase. For zero of as + b vacuum function would be equal to one unless Kähler action is allowed to be infinite: does this make sense?. One can however hope that the values of parameters allow to distinguish between weak and color interactions. It is certainly possible to get an idea about the values of the parameters of the transformation and one ends up with a general model predicting the entire electroweak coupling constant evolution successfully.

To sum up, the big idea is the identification of the spectra of coupling constant strengths as poles of $\zeta_F((as + b/)(cs + d))$ identified as a complex square root of partition function with motivation coming from ZEO, quantum criticality, and super-conformal symmetry; the discretization of the RG flow made possible by the p-adic length scale hypothesis $p \simeq k^k$, k prime; and the assignment of complex zeros of ζ with p-adic primes in increasing order. These assumptions reduce the coupling constant evolution to four real rational or integer valued parameters (a, b, c, d). In the sequel this vision is discussed in more detail.

5.4.7 Other applications of NTU

NTU in the strongest form says that all numbers involved at "basic level" (whatever this means!) of adelic TGD are products of roots of unity and of power of a root of *e*. This is extremely powerful physics inspired conjecture with a wide range of possible mathematical applications.

- 1. For instance, vacuum functional defined as an exponent of action for preferred externals would be number of this kind. One could define functional integral as adelic operation in all number fields: essentially as sum of exponents of action for stationary preferred extremals since Gaussian and metric determinants potentially spoiling NTU would cancel each other leaving only the exponent.
- 2. The implications of NTU for the zeros of Riemann zeta [L39] will be discussed in more detail in the Appendix. Suffice it to say that the observations about Fourier transform for the distribution of loci of non-trivial zeros of zeta together with NTU leads to explicit proposal for the algebraic for of zeros of zeta. The testable proposal is that zeros decompose to disjoint classes C(p) labelled by primes p and the condition that p^{iy} is root of unity in given class C(p).
- 3. NTU generalises to all Lie groups. Exponents $exp(in_i J_i/n)$ of lie-algebra generators define generalisations of number theoretically universal group elements and generate a discrete subgroup of compact Lie group. Also hyperbolic "phases" based on the roots $e^{m/n}$ are possible and make possible discretized NTU versions of all Lie-groups expected to play a key role in adelization of TGD.

NTU generalises also to quaternions and octonions and allows to define them as number theoretically universal entities. Note that ordinary p-adic variants of quaternions and octonions do not give rise to a number field: inverse of quaternion can have vanishing p-adic variant of norm squared satisfying $\sum_n x_n^2 = 0$.

NTU allows to define also the notion of Hilbert space as an adelic notion. The exponents of angles characterising unit vector of Hilbert space would correspond to roots of unity.

5.4.8 Going to the roots of p-adicity

The basic questions raised by the p-adic mass calculations concern the origin of preferred p-adic primes and of p-adic length scale hypothesis. One can also ask whether there might be a natural origin for p-adicity at the level of WCW.

Preferred primes as ramified primes for extensions of rationals?

Preferred primes as ramified primes for extensions of rationals?

The intuitive feeling is that the notion of preferred prime is something extremely deep and to me the deepest thing I know is number theory. Does one end up with preferred primes in number theory? This question brought to my mind the notion of *ramification of primes* (http://tinyurl.com/hddljlf) (more precisely, of prime ideals of number field in its extension), which happens only for special primes in a given extension of number field, say rationals. Ramification is completely analogous to the degeneracy of some roots of polynomial and corresponds to criticality if the polynomial corresponds to criticality (catastrophe theory of Thom is one application). Could this be the mechanism assigning preferred prime(s) to a given elementary system, such as elementary particle? I have not considered their role earlier also their hierarchy is highly relevant in the number theoretical vision about TGD.

1. Stating it very roughly (I hope that mathematicians tolerate this sloppy language of physicist): as one goes from number field K, say rationals Q, to its algebraic extension L, the original prime ideals in the so called *integral closure* (http://tinyurl.com/js6fpvr) over integers of K decompose to products of prime ideals of L (prime ideal is a more rigorous manner to express primeness). Note that the general ideal is analog of integer.

Integral closure for integers of number field K is defined as the set of elements of K, which are roots of some monic polynomial with coefficients, which are integers of K having the form $x^n + a_{n-1}x^{n-1} + ... + a_0$. The integral closures of both K and L are considered. For instance, integral closure of algebraic extension of K over K is the extension itself. The integral closure of complex numbers over ordinary integers is the set of algebraic numbers.

Prime ideals of K can be decomposed to products of prime ideals of L: $P = \prod P_i^{e_i}$, where e_i is the ramification index. If $e_i > 1$ is true for some i, ramification occurs. P_i :s in question are like co-inciding roots of polynomial, which for in thermodynamics and Thom's catastrophe theory corresponds to criticality. Ramification could therefore be a natural aspect of quantum criticality and ramified primes P are good candidates for preferred primes for a given extension of rationals. Note that the ramification make sense also for extensions of given extension of rationals.

- 2. A physical analogy for the decomposition of ideals to ideals of extension is provided by decomposition of hadrons to valence quarks. Elementary particles becomes composite of more elementary particles in the extension. The decomposition to these more elementary primes is of form $P = \prod P_i^{e(i)}$, the physical analog would be the number of elementary particles of type *i* in the state (http://tinyurl.com/h9528pl). Unramified prime *P* would be analogous a state with *e* fermions. Maximally ramified prime would be analogous to Bose-Einstein condensate of *e* bosons. General ramified prime would be analogous to an *e*-particle state containing both fermions and condensed bosons. This is of course just a formal analogy.
- 3. There are two further basic notions related to ramification and characterizing it. Relative discriminant is the ideal divided by all ramified ideals in K (integer of K having no ramified prime factors) and relative different for P is the ideal of L divided by all ramified P_i :s (product of prime factors of P in L). These ideals represent the analogs of product of preferred primes P of K and primes P_i of L dividing them. These two integers ideals would characterize the ramification.

In TGD framework the extensions of rationals (http://tinyurl.com/h9528pl) and p-adic number fields (http://tinyurl.com/zq22tvb) are unavoidable and interpreted as an evolutionary hierarchy physically and cosmological evolution would gradually proceed to more and more complex extensions. One can say that string world sheets and partonic 2-surfaces with parameters of defining functions in increasingly complex extensions of prime emerge during evolution. Therefore ramifications and the preferred primes defined by them are unavoidable. For p-adic number fields the number of extensions is much smaller for instance for p > 2 there are only 3 quadratic extensions.

How could ramification relate to p-adic and adelic physics and could it explain preferred primes?

- 1. Ramified p-adic prime $P = P_i^e$ would be replaced with its e:th root P_i in p-adicization. Same would apply to general ramified primes. Each un-ramified prime of K is replaced with e = K : L primes of L and ramified primes P with $\#\{P_i\} < e$ primes of L: the increase of algebraic dimension is smaller. An interesting question relates to p-adic length scale. What happens to p-adic length scales. Is p-adic prime effectively replaced with e:th root of p-adic prime: $L_p \propto p^{1/2}L_1 \rightarrow p^{1/2e}L_1$? The only physical option is that the p-adic temperature for P would be scaled down $T_p = 1/n \rightarrow 1/ne$ for its e:th root (for fermions serving as fundamental particles in TGD one actually has $T_p = 1$). Could the lower temperature state be more stable and select the preferred primes as maximimally ramified ones? What about general ramified primes?
- 2. This need not be the whole story. Some algebraic extensions would be more favored than others and p-adic view about realizable imaginations could be involved. p-Adic pseudo constants are expected to allow p-adic continuations of string world sheets and partonic 2-surfaces to 4-D preferred extremals with number theoretic discretization. For real continuations the situation is more difficult. For preferred extensions and therefore for corresponding ramified primes the number of real continuations realizable imaginations would be especially large.

The challenge would be to understand why primes near powers of 2 and possibly also of other small primes would be favored. Why for them the number of realizable imaginations would be especially large so that they would be winners in number theoretical fight for survival?

Can one make this picture more concrete? What kind of algebraic extensions could be considered?

- 1. In p-adic context a proper definition of counterparts of angle variables as phases allowing definition of the analogs of trigonometric functions requires the introduction of algebraic extension giving rise to some roots of unity. Their number depends on the angular resolution. These roots allow to define the counterparts of ordinary trigonometric functions the naive generalization based on Taylors series is not periodic and also allows to defined the counterpart of definite integral in these degrees of freedom as discrete Fourier analysis. For the simplest algebraic extensions defined by $x^n 1$ for which Galois group is abelian are are unramified so that something else is needed. One has decomposition $P = \prod P_i^{e(i)}$, e(i) = 1, analogous to *n*-fermion state so that simplest cyclic extension does not give rise to a ramification and there are no preferred primes.
- 2. What kind of polynomials could define preferred algebraic extensions of rationals? Irreducible polynomials are certainly an attractive candidate since any polynomial reduces to a product of them. One can say that they define the elementary particles of number theory. Irreducible polynomials have integer coefficients having the property that they do not decompose to products of polynomials with rational coefficients. It would be wrong to say that only these algebraic extensions can appear but there is a temptation to say that one can reduce the study of extensions to their study. One can even consider the possibility that string world sheets associated with products of irreducible polynomials are unstable against decay to those characterize irreducible polynomials.
- 3. What can one say about irreducible polynomials? Eisenstein criterion (http://tinyurl. com/47kxjz states following. If $Q(x) = \sum_{k=0,..,n} a_k x^k$ is n:th order polynomial with integer coefficients and with the property that there exists at least one prime dividing all coefficients a_i except a_n and that p^2 does not divide a_0 , then Q is irreducible. Thus one can assign one or more preferred primes to the algebraic extension defined by an irreducible polynomial Q of this kind in fact any polynomial allowing ramification. There are also other kinds of irreducible polynomials since Eisenstein's condition is only sufficient but not necessary.

Furthermore, in the algebraic extension defined by Q, the prime ideals P having the above mentioned characteristic property decompose to an *n*:th power of single prime ideal P_i : $P = P_i^n$. The primes are maximally/completely ramified.

A good illustration is provided by equations $x^2 + 1 = 0$ allowing roots $x_{\pm} = \pm i$ and equation $x^2 + 2px + p = 0$ allowing roots $x_{\pm} = -p \pm \sqrt{p}p - 1$. In the first case the ideals associated with

 $\pm i$ are different. In the second case these ideals are one and the same since $x_{+} == -x_{-} + p$: hence one indeed has ramification. Note that the first example represents also an example of irreducible polynomial, which does not satisfy Eisenstein criterion. In more general case the n conditions on defined by symmetric functions of roots imply that the ideals are one and same when Eisenstein conditions are satisfied.

4. What is so nice that one could readily construct polynomials giving rise to given preferred primes. The complex roots of these polymials could correspond to the points of partonic 2-surfaces carrying fermions and defining the ends of boundaries of string world sheet. It must be however emphasized that the form of the polynomial depends on the choices of the complex coordinate. For instance, the shift $x \to x + 1$ transforms $(x^n - 1)/(x - 1)$ to a polynomial satisfying the Eisenstein criterion. One should be able to fix allowed coordinate changes in such a manner that the extension remains irreducible for all allowed coordinate changes.

Already the integral shift of the complex coordinate affects the situation. It would seem that only the action of the allowed coordinate changes must reduce to the action of Galois group permuting the roots of polynomials. A natural assumption is that the complex coordinate corresponds to a complex coordinate transforming linearly under subgroup of isometries of the imbedding space.

In the general situation one has $P = \prod P_i^{e(i)}$, $e(i) \ge 1$ so that alo now there are preferred primes so that the appearance of preferred primes is completely general phenomenon.

The origin of p-adic length scale hypothesis?

p-Adic length scale hypothesis emerged from p-adic length scale hypothesis. A possible generalization of this hypothesis is that p-adic primes near powers of prime are physically favored. There indeed exists evidence for the realization of 3-adic time scale hierarchies in living matter [I98] (http://tinyurl.com/jbh9m27) and in music both 2-adicity and 3-adicity could be present: this is discussed in TGD inspired theory of music harmony and genetic code [K102]. See also [L61, L48].

One explanation would be that for preferred primes the number of p-adic space-time sheets representable also as real space-time sheets is maximal. Imagined worlds would be maximally realizable. Preferred p-adic primes would correspond to ramified primes for extensions with the property that the number of realizable imaginations is especially large for them. Why primes satisfying p-adic length scale hypothesis or its generalization would appear as ramified primes for extensions, which are winners in number theoretical evolution?

Also the weak form of NMP (WNMP) applying also to the purely number theoretic form of NMP [K80] might come in rescue here.

- 1. Entanglement negentropy for a NE [K80] characterized by n-dimensional projection operator is the $log(N_p(n))$ for some p whose power divides n. The maximum negentropy is obtained if the power of p is the largest power of prime divisor of p, and this can be taken as definition of number theoretical entanglement negentropy (NEN). If the largest divisor is p^k , one has $N = k \times log(p)$. The entanglement negentropy per entangled state is N/n = klog(p)/n and is maximal for $n = p^k$. Hence powers of prime are favoured, which means that p-adic length scale hierarchies with scales coming as powers of p are negentropically favored and should be generated by NMP. Note that $n = p^k$ would define a hierarchy of $h_{eff}/h = p^k$. During the first years of h_{eff} hypothesis I believe that the preferred values obey $h_{eff} = r^k$, r integer not far from $r = 2^{11}$. It seems that this belief was not totally wrong.
- 2. If one accepts this argument, the remaining challenge is to explain why primes near powers of two (or more generally p) are favoured. $n = 2^k$ gives large entanglement negentropy for the final state. Why primes $p = n_2 = 2^k r$ would be favored? The reason could be following. $n = 2^k$ corresponds to p = 2, which corresponds to the lowest level in p-adic evolution since it is the simplest p-adic topology and farthest from the real topology and therefore gives the poorest cognitive representation of real PE as p-adic PE (Note that p = 1 makes formally sense but for it the topology is discrete).

- 3. WNMP [K80, K139] suggests a more feasible explanation. The density matrix of the state to be reduced is a direct sum over contributions proportional to projection operators. Suppose that the projection operator with largest dimension has dimension n. Strong form of NMP would say that final state is characterized by n-dimensional projection operator. WNMP allows "free will" so that all dimensions n - k, k = 0, 1, ..., n - 1 for final state projection operator are possible. 1-dimensional case corresponds to vanishing entanglement negentropy and ordinary state function reduction isolating the measured system from external world.
- 4. The negentropy of the final state per state depends on the value of k. It is maximal if n-k is power of prime. For $n = 2^k = M_k + 1$, where M_k is Mersenne prime n-1 gives the maximum negentropy and also maximal p-adic prime available so that this reduction is favoured by NMP. Mersenne primes would be indeed special. Also the primes $n = 2^k r$ near 2^k produce large entanglement negentropy and would be favored by NMP.
- 5. This argument suggests a generalization of p-adic length scale hypothesis so that p = 2 can be replaced by any prime.

5.5 p-Adic physics and consciousness

p-Adic physics as physics of cognition and imagination is an important thread in TGD inspired theory of consciousness. In the sequel I describe briefly the basic of TGD inspired theory of consciousness as generalization of quantum measurement theory to ZEO (ZEO), describe the definition of self, consider the question whether NMP is needed as a separate principle or whether it is implied is in statistical sense by the unavoidable statistical increase of $n = h_{eff}/h$ if identified as a factor of the dimension of Galois group extension of rationals defining the adeles, and finally summarize the vision about how p-adic physics serves as a correlate of cognition and imagination.

5.5.1 From quantum measurement theory to a theory of consciousness

The notion of self can be seen as a generalization of the poorly defined definition of the notion of observer in quantum physics. In the following I take the role of skeptic trying to be as critical as possible.

The original definition of self was as a subsystem able to remain unentangled under state function reductions associated with subsequent quantum jumps. The density matrix was assumed to define the universal observable. Note that a density matrix, which is power series of a product of matrices representing commuting observables has in the generic case eigenstates, which are simultaneous eigenstates of all observables. Second aspect of self was assumed to be the integration of subsequent quantum jumps to coherent whole giving rise to the experienced flow of time.

The precise identification of self allowing to understand both of these aspects turned out to be difficult problem. I became aware the solution of the problem in terms of ZEO (ZEO) only rather recently (2014).

- 1. Self corresponds to a sequence of quantum jumps integrating to single unit as in the original proposal, but these quantum jumps correspond to state function reductions to a fixed boundary of causal diamond CD leaving the corresponding parts of zero energy states invariant "small" state function reductions. The parts of zero energy states at second boundary of CD change and even the position of the tip of the opposite boundary changes: one actually has wave function over positions of second boundary (CD sizes roughly) and this wave function changes. In positive energy ontology these repeated state function reductions would have no effect on the state (Zeno effect) but in TGD framework there occurs a change for the second boundary and gives rise to the experienced flow of time and its arrow and self: self is generalized Zeno effect.
- 2. The first quantum jump to the opposite boundary corresponds to the act of "free will" or birth of re-incarnated self. Hence the act of "free will" changes the arrow of psychological time at some level of hierarchy of CDs. The first reduction to the opposite boundary of CD means "death" of self and "re-incarnation" of time-reversed self at opposite boundary at which the the temporal distance between the tips of CD increases in opposite direction. The

sequence of selves and time reversed selves is analogous to a cosmic expansion for CD. The repeated birth and death of mental images could correspond to this sequence at the level of sub-selves.

3. This allows to understand the relationship between subjective and geometric time and how the arrow of and flow of clock time (psychological time) emerge. The average distance between the tips of CD increases on the average as along as state function functions occur repeatedly at the fixed boundary: situation is analogous to that in diffusion. The localization of contents of conscious experience to boundary of CD gives rise to the illusion that universe is 3-dimensional. The possibility of memories made possibly by hierarchy of CDs demonstrates that this is not the case. Self is simply the sequence of state function reductions at same boundary of CD remaining fixed and the lifetime of self is the total growth of the average temporal distance between the tips of CD.

One can identify several rather abstract state function reductions selecting a sector of WCW.

- 1. There are quantum measurements inducing localization in the moduli space of CDs with passive boundary and states at it fixed. In particular, a localization in the moduli characterizing the Lorentz transform of the upper tip of CD would be measured. The measured moduli characterize also the analog of symplectic form in M^4 strongly suggested by twistor lift of TGD - that is the rest system (time axis) and spin quantization axes. Of course, also other kinds of reductions are possible.
- 2. Also a localization to an extension of rationals defining the adeles should occur. Could the value of $n = h_{eff}/h$ be observable? The value of n for given space-time surface at the active boundary of CD could be identified as the order of the smallest Galois group containing all Galois groups assignable to 3-surfaces at the boundary. The superposition of space-time surface would not be eigenstate of n at active boundary unless localization occurs. It is not obvious whether this is consistent with a fixe value of n at passive boundary.

The measured value of n could be larger or smaller than the value of n at the passive boundary of CD but in statistical sense n would increase by the analogy with diffusion on half line defined by non-negative integers. The distance from the origin unavoidably increases in statistical sense. This would imply evolution as increase of maximal value of negentropy and generation of quantum coherence in increasingly longer scales.

3. A further abstract choice corresponds to the the replacement of the roles of active and passive boundary of CD changing the arrow of clock time and correspond to a death of self and reincarnation as time-reversed self.

Can one assume that these measurements reduce to measurements of a density matrix of either entangled system as assumed in the earlier formulation of NMP, or should one allow both options. This question actually applies to all quantum measurements and leads to a fundamental philosophical questions unavoidable in all consciousness theories.

1. Do all measurements involve entanglement between the moduli or extensions of two CDs reduced in the measurement of the density matrix? Non-diagonal entanglement would allow final states states, which are not eigenstates of moduli or of *n*: this looks strange. This could also lead to an infinite regress since it seems that one must assume endless hierarchy of entangled CDs so that the reduction sequence would proceed from top to bottom. It looks natural to regard single CD as a sub-Universe.

For instance, if a selection of quantization axis of color hypercharge and isospin (localization in the twistor space of CP_2) is involved, one would have an outcome corresponding to a quantum superposition of measurements with different color quantization axis!

Going philosophical, one can also argue, that the measurement of density matrix is only a reaction to environment and does not allow intentional free will.

2. Can one assume that a mere localization in the moduli space or for the extension of rationals (producing an eigenstate of n) takes place for a fixed CD - a kind of self measurement possible

for even unentangled system? If there is entanglement in these degrees of freedom between two systems (say CDs), it would be reduced in these self measurements but the outcome would not be an eigenstate of density matrix. An interpretation as a realization of intention would be approriate.

- 3. If one allows both options, the interpretation would be that state function reduction as a measurement of density matrix is only a reaction to environment and self-measurement represents a realization of intention.
- 4. Self measurements would occur at higher level say as a selection of quantization axis, localization in the moduli space of CD, or selection of extension of rationals. A possible general rule is that measurements at space-time level are reactions as measurements of density matrix whereas a selection of a sector of WCW would be an intentional action. This because formally the quantum states at the level of WCW are as modes of classical WCW spinor field single particle states.
- 5. If the selections of sectors of WCW at active boundary of CD commute with observables, whose eigenstates appear at passive boundary (briefly *passive observables*) meaning that time reversal commutes with them they can occur repeatedly during the reduction sequence and self as a generalized Zeno effect makes sense.

If the selections of WCW sectors at active boundary do not commute with passive observables then volition as a choice of sector of WCW must change the arrow of time. Libet's findings show that conscious choice induces neural activity for a fraction of second before the conscious choice. This would imply the correspondences "big" measurement changing the arrow of time - self-measurement at the level of WCW - intentional action and "small" measurement - measurement at space-time level - reaction.

Self as a generalized Zeno effect makes sense only if there are active commuting with passive observables. If the passive observables form a maximal set, the new active observables commuting with them must emerge. The increase of the size of extension of rationals might generate them by expanding the state space so that self would survive only as long at it evolves.

Otherwise there would be only single unitary time evolution followed by a reduction to opposite boundary. This makes sense only if the sequence of "big" reductions for sub-selves can give rise to the time flow experienced by self: the birth and death of mental images would give rise to flow of time of self.

A hierarchical process starting from given CD and proceeding downwards to shorter scales and stopping when the entanglement is stable is highly suggestive and favors self measurements. What stability could mean will be discussed in the next section. CDs would be a correlate for self hierarchy. One can say also something about the anatomy and correlates of self hierarchy.

- 1. Self experiences its sub-selves as mental images and even we would represent mental images of some higher level collective self. Everything is conscious but consciousness can be lost or at least it is not possible to have memory about it. The flow of consciousness for a given self could be due to the quantum jump sequences performed by its sub-selves giving rise to mental images.
- 2. By quantum classical correspondence self has also space-time correlates. One can visualize sub-self as a space-time sheet "glued" by topological sum to the space-time sheet of self. Subsystem is not described as a tensor factor as in the standard description of subsystems. Also sub-selves of selves can entangle negentropically and this gives rise to a sharing of mental images about which stereo vision would be basic example. Quite generally, one could speak of stereo consciousness. Also the experiences of sensed presence [J95] could be understood as a sharing of mental images between brain hemispheres, which are not themselves entangled.

3. At the level of 8-dimensional imbedding space the natural correlate of self would be CD (causal diamond). At the level of space-time the correlate would be space-time sheet or light-like 3-surface. The contents of consciousness of self would be determined by the space-time sheets in the interior of CD. Without further restrictions the experience of self would be essentially four-dimensional. Memories would be like sensory experiences except that they would be about the geometric past and for some reason are not usually colored by sensory qualia. For instance .1 second time scale defining sensory chronon corresponds to the secondary p-adic time scale characterizing the size of electron's CD (Mersenne prime M_{127}), which suggests that Cooper pairs of electrons are essential for the sensory qualia.

5.5.2 NMP and self

The view about Negentropy Maximization Principle (NMP) [K80] has co-evolved with the notion of self and I have considered many variants of NMP.

- 1. The original formulation of NMP was in positive energy ontology and made same predictions as standard quantum measurement theory. The new element was that the density matrix of sub-system defines the fundamental observable and the system goes to its eigenstate in state function reduction. As found, the localizations at to WCW sectors define what might be called self-measurements and identifiable as active volitions rather than reactions.
- 2. In p-adic physics one can assign with rational and even algebraic entanglement probabilities number theoretical entanglement negentropy (NEN) satisfying the same basic axioms as the ordinary Shannon entropy but having negative values and therefore having interpretation as information. The definition of p-adic negentropy (real valued) reads as $S_p = -\sum P_k log(|P_k|_p)$, where $|.|_p$ denotes p-adic norm. The news is that $N_p = -S_p$ can be positive and is positive for rational entanglement probabilities. Real entanglement entropy S is always non-negative.

NMP would force the generation of negentropic entanglement (NE) and stabilize it. NNE resources of the Universe - one might call them Akashic records- would steadily increase.

3. A decisive step of progress was the realization is that NTU forces all states in adelic physics to have entanglement coefficients in some extension of rationals inducing finite-D extension of p-adic numbers. The same entanglement can be characterized by real entropy S and p-adic negentropies N_p , which can be positive. One can define also total p-adic negentropy: $N = \sum_p N_p$ for all p and total negentropy $N_{tot} = N - S$.

For rational entanglement probabilities it is easy to demonstrate that the generalization of adelic theorem holds true: $N_{tot} = N - S = 0$. NMP based on N_{tot} rather than N would not say anything about rational entanglement. For extensions of rationals it is easy to find that N - S > 0 is possible if entanglement probabilities are of form X_i/n with $|X_i|_p = 1$ and n integer [L53]. Should one identify the total negentropy as difference $N_{tot} = N - S$ or as $N_{tot} = N$?

Irrespective of answer, large p-adic negentropy seems to force large real entropy: this nicely correlates with the paradoxical finding that living systems tend to be entropic although one would expect just the oppositecite [L53]: this relates in very interesting manner to the work of biologists Jeremy England [I114]. The negentropy would be cognitive negentropy and not visible for ordinary physics.

4. The latest step in the evolution of ideas NMP was the question whether NMP follows from number theory alone just as second law follows form probability theory! This irritates theoretician's ego but is victory for theory. The dimension n of extension is positive integer and cannot but grow in statistical sense in evolution! Since one expects that the maximal value of negentropy (define as N-S) must increase with n. Negentropy must increase in long run.

Number theoretic entanglement can be stable

Number theoretical Shannon entropy can serve as a measure for genuine information assignable to a pair of entanglement systems [K80]. Entanglement with coefficients in the extension is always negentropic if entanglement negentropy comes from p-adic sectors only. It can be negentropic if negentropy is defined as the difference of p-adic negentropy and real entropy.

The diagonalized density matrix need not belong to the algebraic extension since the probabilities defining its diagonal elements are eigenvalues of the density matrix as roots of N:th order polynomial, which in the generic case requires n-dimensional algebraic extension of rationals. One can argue that since diagonalization is not possible, also state function reduction selecting one of the eigenstates is impossible unless a phase transition increasing the dimension of algebraic extension used occurs simultaneously. This kind of NE could give rise to cognitive entanglement.

There is also a special kind of NE, which can result if one requires that density matrix serves a universal observable in state function reduction. The outcome of reduction must be an eigen space of density matrix, which is projector to this subspace acting as identity matrix inside it. This kind NE allows all unitarily related basis as eigenstate basis (unitary transformations must belong to the algebraic extension). This kind of NE could serve as a correlate for "enlightened" states of consciousness. Schrödingers cat is in this kind of state stably in superposition of dead and alive and state basis obtained by unitary rotation from this basis is equally good. One can say that there are no discriminations in this state, and this is what is claimed about "enlightened" states too.

The vision about number theoretical evolution suggests that NMP forces the generation of NE resources as NE assignable to the "passive" boundary of CD for which no changes occur during sequence of state function reductions defining self. It would define the unchanging self as negentropy resources, which could be regarded as kind of Akashic records. During the next "re-incarnation" after the first reduction to opposite boundary of CD the NE associated with the reduced state would serve as new Akashic records for the time reversed self. If NMP reduces to the statistical increase of $h_{eff}/h = n$ the consciousness information contents of the Universe increases in statistical sense. In the best possible world of SNMP it would increase steadily.

Does NMP reduce to number theory?

The heretic question that emerged quite recently is whether NMP is actually needed at all! Is NMP a separate principle or could NMP reduced to mere number theory [K80]? Consider first the possibility that NMP is not needed at all as a separate principle.

- 1. The value of $h_{eff}/h = n$ should increase in the evolution by the phase transitions increasing the dimension of the extension of rationals. $h_{eff}/h = n$ has been identified as the number of sheets of some kind of covering space. The Galois group of extension acts on number theoretic discretizations of the monadic surface and the orbit defines a covering space. Suppose n is the number of sheets of this covering and thus the dimension of the Galois group for the extension of rationals or factor of it.
- 2. It has been already noticed that the "big" state function reductions giving rise to death and reincarnation of self could correspond to a measurement of $n = h_{eff}$ implied by the measurement of the extension of the rationals defining the adeles. The statistical increase of n follows automatically and implies statistical increase of maximal entanglement negentropy. Entanglement negentropy increases in statistical sense.

The resulting world would not be the best possible one unlike for a strong form of NMP demanding that negentropy does increases in "big" state function reductions. n also decrease temporarily and they seem to be needed. In TGD inspired model of bio-catalysis the phase transition reducing the value of n for the magnetic flux tubes connecting reacting bio-molecules allows them to find each other in the molecular soup. This would be crucial for understanding processes like DNA replication and transcription.

3. State function reduction corresponding to the measurement of density matrix could occur to an eigenstate/eigenspace of density matrix only if the corresponding eigenvalue and eigenstate/eigenspace is expressible using numbers in the extension of rationals defining the adele considered. In the generic case these numbers belong to N-dimensional extension of the original extension. This can make the entanglement stable with respect to state the measurements of density matrix. A phase transition to an extension of an extension containing these coefficients would be required to make possible reduction. A step in number theoretic evolution would occur. Also an entanglement of measured state pairs with those of measuring system in containing the extension of extension would make possible the reduction. Negentropy could be reduced but higher-D extension would provide potential for more negentropic entanglement and NMP would hold true in the statistical sense.

4. If one has higher-D eigen space of density matrix, p-adic negentropy is largest for the entire subspace and the sum of real and p-adic negentropies vanishes for all of them. For negentropy identified as total p-adic negentropy SNMP would select the entire sub-space and NMP would indeed say something explicit about negentropy.

Or is NMP needed as a separate principle?

Hitherto I have postulated NMP as a separate principle [K80]. Strong form of NMP (SNMP) states that Negentropy does not decrease in "big" state function reductions corresponding to death and re-incarnations of self.

One can however argue that SNMP is not realistic. SNMP 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. Giving up separate NMP altogether would allow to have also "Good" and "Evil".

This forces to consider what I christened weak form of NMP (WNMP). Instead of maximal dimension corresponding to N-dimensional projector self can choose also lower-dimensional subspaces and 1-D sub-space corresponds to the vanishing entanglement and negentropy assumed in standard quantum measurement theory. As a matter fact, this can also lead to larger negentropy gain since negentropy depends strongly on what is the large power of p in the dimension of the resulting eigen sub-space of density matrix. This could apply also to the purely number theoretical reduction of NMP.

WNMP suggests how to understand the notions of Good and Evil. Various choices in the state function reduction would correspond to Boolean algebra, which suggests an interpretation in terms of what might be called emotional intelligence [K139]. Also it turns out that one can understand how p-adic length scale hypothesis - actually its generalization - emerges from WNMP [K142].

1. 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 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? Recall that WNMP allows only the possibility to generate NNE but does not force it. WNMP would be like God allowing the possibility to do good but not forcing good deeds.

Self can choose any sub-space of the subspace defined by $k \leq N$ -dimensional projector and 1-D subspace corresponds to the standard quantum measurement. For k = 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 NE corresponds to conscious experience with positive emotional coloring. Interestingly, there are $2^k - 1$ possible choices, which is almost the dimension of Boolean algebra consisting of k 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. 2. A map of different choices of k-dimensional sub-spaces 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 k positions. Now it must have $2^k - 1$ positions. To the discrete space of k 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 k-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.

The cautious conclusion is that NMP as a separate principle is not necessary and follows in statistical sense from the unavoidable increase of $n = h_{eff}/h$ identified as dimension of extension of rationals define the adeles if this extension or at least the dimension of its Galois group is observable.

5.5.3 p-Adic physics as correlate of cognition and imagination

The items in the following list give motivations for the proposal that p-adic physics could serve as a correlate for cognition and imagination.

- 1. By the total disconnectedness of the p-adic topology, p-adic world decomposes naturally into blobs, objects. This happens also in sensory perception. The pinary digits of p-adic number can be assigned to a *p*-tree. Parisi proposed in the model of spin glass [B17] that p-adic numbers could relate to the mathematical description of cognition and also Khrennikov [J14] has developed this idea. In TGD framework that idea is taken to space-time level: p-adic space-time sheets represent thought bubbles and they correlate with the real ones since they form cognitive reprentations of the real world. SH allows a concrete realization of this.
- 2. p-Adic non-determinism due to p-adic pseudo constants suggests interpretation in terms of imagination. Given 2-surfaces could allow completion to p-adic preferred extremal but not to a real one so that pure "non-realizable" imagination is in question.
- 3. Number theoretic negentropy has interpretation as negentropy characterizing information content of entanglement. The superposition of state pairs could be interpreted as a quantum representation for a rule or abstracted association containing its instances as state pairs. Number theoretical negentropy characterizes the relationship of two systems and should not be confused with thermodynamical entropy, which characterizes the uncertainty about the state of single system.

The original vision was that p-adic non-determinism could serve as a correlate for cognition, imagination, and intention. The recent view is much more cautious. Imagination need not completely reduce to p-adic non-determinism since it has also real physics correlates - maybe as partial realizations of SH as in nerve pulse pattern, which does not propagate down to muscles.

A possible interpretation for the solutions of the p-adic field equations would be as geometric correlates of cognition, imagination, and perhaps even intentionality. Plans, intentions, expectations, dreams, and possibly also cognition as imagination in general could have p-adic cognitive space-time sheets as their geometric correlates. A deep principle seems to be involved: incompleteness is the characteristic feature of p-adic physics but the flexibility made possible by this incompleteness is absolutely essential for imagination and cognitive consciousness in general.

The most feasible view is that the intersections of p-adic and real space-time surfaces define cognitive representations of real space-time surfaces (PEs, [K21, K14, K19]). One could also say

that real space-time surface represents sensory aspects of conscious experience and p-adic spacetime surfaces its cognitive aspects. Both real and p-adics rather than real or p-adics.

The identification of p-adic pseudo constants as correlates of imagination at space-time level is indeed a further natural idea.

- 1. The construction of PEs by SH from the data at 2-surfaces is like boundary value problem with number theoretic discretization of space-time surface as additional data. PE property in real context implies strong correlations between string world sheets and partonic 2-surfaces by boundary conditions a them. One cannot choose these 2-surfaces completely independently in real context.
- 2. In p-adic sectors the integration constants are replaced with pseudo-constants depending on finite number of pinary digits of variables depending on coordinates normal to string world sheets and partonic 2-surfaces. The fixing of the discretization of space-time surface would allow to fix the p-adic pseudo-constants. Once the number theoretic discretization of space-time surface is fixed, the p-adic pseudo-constants can be fixed. Pseudo-constant could allow a large number of p-adic configurations involving string world sheets, partonic 2-surfaces, and number theoretic discretization but not allowed in real context.

Could these p-adic PEs correspond to imaginations, which in general are not realizable? Could the realizable intentional actions belong to the intersection of real and p-adic WCWs? Could one identify non-realistic imaginations as the modes of WCW spinor fields for which 2surfaces are not extendable to real space-time surfaces and are localized to 2-surfaces? Could they allow only a partial continuation to real space-time surface. Could nerve pulse pattern representing imagined motor action and not proceeding to the level of muscles correspond to a partially real PE?

Could imagination and problem solving be search for those collections of string world sheets and partonic 2-surfaces, which allow extension to (realization as) real PEs? If so, p-adic physics would be there as an independent aspect of existence and this is just the original idea. Imagination could be realized in state function reduction, which always selects only those 2surfaces, which allow continuation to real space-time surfaces. The distinction between only imaginable and also realizable would be the extendability by using strong form of holography.

3. An interesting question is why elementary particles are characterized by preferred p-adic primes (primes near powers of 2, in particular Mersenne primes). Could the number of realizable imaginations for these primes be especially large?

I have the feeling that this view allows respectable mathematical realization of imagination in terms of adelic quantum physics. It is remarkable that SH derivable from - you can guess, SGCI (the Big E again!), plays an absolutely central role in it.

5.6 Appendix: Super-symplectic conformal weights and zeros of Riemann zeta

Since fermions are the only fundamental particles in TGD one could argue that the conformal weight of for the generating elements of supersymplectic algebra could be negatives for the poles of fermionic zeta ζ_F . This demands n > 0 as does also the fractal hierarchy of supersymplectic symmetry breakings. NTU of Riemann zeta in some sense is strongly suggested if adelic physics is to make sense.

For ordinary conformal algebras there are only finite number of generating elements ($-2 \le n \le 2$). If the radial conformal weights for the generators of g consist of poles of ζ_F , the situation changes. ζ_F is suggested by the observation that fermions are the only fundamental particles in TGD.

1. Riemann Zeta $\zeta(s) = \prod_p (1/(1-p^{-s}))$ identifiable formally as a partition function $\zeta_B(s)$ of arithmetic boson gas with bosons with energy log(p) and temperature 1/s = 1/(1/2 + iy) should be replaced with that of arithmetic fermionic gas given in the product representation by $\zeta_F(s) = \prod_p (1+p^{-s})$ so that the identity $\zeta_B(s)/\zeta_F(s) = \zeta_B(2s)$ follows. This gives

$$\frac{\zeta_B(s)}{\zeta_B(2s)}$$

 $\zeta_F(s)$ has zeros at zeros s_n of $\zeta(s)$ and at the pole s = 1/2 of zeta(2s). $\zeta_F(s)$ has poles at zeros $s_n/2$ of $\zeta(2s)$ and at pole s = 1 of $\zeta(s)$.

The spectrum of 1/T would be for the generators of algebra $\{(-1/2+iy)/2, n > 0, -1\}$. In padic thermodynamics the p-adic temperature is 1/T = 1/n and corresponds to "trivial" poles of ζ_F . Complex values of temperature does not make sense in ordinary thermodynamics. In ZEO quantum theory can be regarded as a square root of thermodynamics and complex temperature parameter makes sense.

2. If the spectrum of conformal weights of the generating elements of the algebra corresponds to poles serving as analogs of propagator poles, it consists of the "trivial" conformal h = n > 0-the standard spectrum with h = 0 assignable to massless particles excluded - and "non-trivial" h = -1/4 + iy/2. There is also a pole at h = -1.

Both the non-trivial pole with real part $h_R = -1/4$ and the pole h = -1 correspond to tachyons. I have earlier proposed conformal confinement meaning that the total conformal weight for the state is real. If so, one obtains for a conformally confined two-particle states corresponding to conjugate non-trivial zeros in minimal situation $h_R = -1/2$ assignable to N-S representation.

In p-adic mass calculations ground state conformal weight must be -5/2 [K74]. The negative fermion ground state weight could explain why the ground state conformal weight must be tachyonic -5/2. With the required 5 tensor factors one would indeed obtain this with minimal conformal confinement. In fact, arbitrarily large tachyonic conformal weight is possible but physical state should always have conformal weights h > 0.

3. h = 0 is not possible for generators, which reminds of Higgs mechanism for which the naïve ground states corresponds to tachyonic Higgs. h = 0 conformally confined massless states are necessarily composites obtained by applying the generators of Kac-Moody algebra or super-symplectic algebra to the ground state. This is the case according to p-adic mass calculations [K74], and would suggest that the negative ground state conformal weight can be associated with super-symplectic algebra and the remaining contribution comes from ordinary super-conformal generators. Hadronic masses, whose origin is poorly understood, could come from super-symplectic degrees of freedom. There is no need for p-adic thermodynamics in super-symplectic degrees of freedom.

5.6.1 A general formula for the zeros of zeta from NTU

Dyson's comment about Fourier transform of Riemann Zeta [A29] (http://tinyurl.com/hjbfsuv) is interesting from the point of NTU for Riemann zeta.

- 1. The numerical calculation of Fourier transform for the imaginary parts iy of zeros s = 1/2+iy of zeta shows that it is concentrated at discrete set of frequencies coming as $log(p^n)$, p prime. This translates to the statement that the zeros of zeta form a 1-dimensional quasicrystal, a discrete structure Fourier spectrum by definition is also discrete (this of course holds for ordinary crystals as a special case). Also the logarithms of powers of primes would form a quasicrystal, which is very interesting from the point of view of p-adic length scale hypothesis. Primes label the "energies" of elementary fermions and bosons in arithmetic number theory, whose repeated second quantization gives rise to the hierarchy of infinite primes [K124]. The energies for general states are logarithms of integers.
- 2. Powers p^n label the points of quasicrystal defined by points $log(p^n)$ and Riemann zeta has interpretation as partition function for boson case with this spectrum. Could p^n label also the points of the dual lattice defined by iy.
- 3. The existence of Fourier transform for points $log(p_i^n)$ for any vector y_a in class C(p) of zeros labelled by p requires $p_i^{iy_a}$ to be a root of unity inside C(p). This could define the sense in

which zeros of zeta are universal. This condition also guarantees that the factor $n^{-1/2-iy}$ appearing in zeta at critical line are number theoretically universal ($p^{1/2}$ is problematic for Q_p : the problem might be solved by eliminating from p-adic analog of zeta the factor $1-p^{-s}$.

(a) One obtains for the pair (p_i, s_a) the condition $log(p_i)y_a = q_{ia}2\pi$, where q_{ia} is a rational number. Dividing the conditions for (i, a) and (j, a) gives

$$p_i = p_j^{q_{ia}/q_{ja}}$$

for every zero s_a so that the ratios q_{ia}/q_{ja} do not depend on s_a . From this one easily deduce $p_i^M = p_j^N$, where M and N are integers so that one ends up with a contradiction.

(b) Dividing the conditions for (i, a) and (i, b) one obtains

$$\frac{y_a}{y_b} = \frac{q_{ia}}{q_{ib}}$$

so that the ratios q_{ia}/q_{ib} do not depend on p_i . The ratios of the imaginary parts of zeta would be therefore rational number which is very strong prediction and zeros could be mapped by scaling y_a/y_1 where y_1 is the zero which smallest imaginary part to rationals.

(c) The impossible consistency conditions for (i, a) and (j, a) can be avoided if each prime and its powers correspond to its own subset of zeros and these subsets of zeros are disjoint: one would have infinite union of sub-quasicrystals labelled by primes and each p-adic number field would correspond to its own subset of zeros: this might be seen as an abstract analog for the decomposition of rational to powers of primes. This decomposition would be natural if for ordinary complex numbers the contribution in the complement of this set to the Fourier trasform vanishes. The conditions (i, a) and (i, b) require now that the ratios of zeros are rationals only in the subset associated with p_i .

For the general option the Fourier transform can be delta function for $x = log(p^k)$ and the set $\{y_a(p)\}$ contains N_p zeros. The following argument inspires the conjecture that for each p there is an infinite number N_p of zeros $y_a(p)$ in class C(p) satisfying

$$p^{iy_a(p)} = u(p) = e^{\frac{r(p)}{m(p)}i2\pi}$$

where u(p) is a root of unity that is $y_a(p) = 2\pi (m(a) + r(p))/log(p)$ and forming a subset of a lattice with a lattice constant $y_0 = 2\pi /log(p)$, which itself need not be a zero.

In terms of stationary phase approximation the zeros $y_a(p)$ associated with p would have constant stationary phase whereas for $y_a(p_i \neq p)$) the phase $p^{iy_a(p_i)}$ would fail to be stationary. The phase e^{ixy} would be non-stationary also for $x \neq log(p^k)$ as function of y.

- 1. Assume that for x = qlog(p), where q not a rational, the phases e^{ixy} fail to be roots of unity and are random implying the vanishing/smallness of F(x).
- 2. Assume that for a given p all powers p^{iy} for $y \notin \{y_a(p)\}$ fail to be roots of unity and are also random so that the contribution of the set $y \notin \{y_a(p)\}$ to F(p) vanishes/is small.
- 3. For $x = log(p^{k/m})$ the Fourier transform should vanish or be small for $m \neq 1$ (rational roots of primes) and give a non-vanishing contribution for m = 1. One has

$$\begin{aligned} F(x = \log(p^{k/m}) &= \sum_{1 \le a \le N(p)} e^{k \frac{M(a,p)}{mN(p)} i 2\pi} u(p) ,\\ u(p) &= e^{\frac{r(p)}{m(p)} i 2\pi} . \end{aligned}$$

Obviously one can always choose N(a, p) = N(p).

4. For the simplest option N(p) = 1 one would obtain delta function distribution for $x = log(p^k)$. The sum of the phases associated with $y_a(p)$ and $-y_a(p)$ from the half axes of the critical line would give

$$F(x = log(p^n)) \propto X(p^n) \equiv 2cos(n\frac{r(p)}{m(p)}2\pi)$$

The sign of F would vary.

- 5. For $x = log(p^{k/m})$ the value of Fourier transform is expected to be small by interference effects if M(a, p) is random integer, and negligible as compared with the value at $x = log(p^k)$. This option is highly attractive. For N(p) > 1 and M(a, p) a random integer also $F(x = log(p^k))$ is small by interference effects. Hence it seems that this option is the most natural one.
- 6. The rational r(p)/m(p) would characterize given prime (one can require that r(p) and m(p) have no common divisors). F(x) is non-vanishing for all powers $x = log(p^n)$ for m(p) odd. For p = 2, also m(2) = 2 allows to have $|X(2^n)| = 2$. An interesting ad hoc ansatz is m(p) = p or $p^{s(p)}$. One has periodicity in n with period m(p) that is logarithmic wave. This periodicity serves as a test and in principle allows to deduce the value of r(p)/m(p) from the Fourier transform.

What could one conclude from the data (http://tinyurl.com/hjbfsuv)?

1. The first graph gives $|F(x = log(p^k)|$ and second graph displays a zoomed up part of $|F(x = log(p^k)|$ for small powers of primes in the range [2, 19]. For the first graph the eighth peak (p = 11) is the largest one but in the zoomed graphs this is not the case. Hence something is wrong or the graphs correspond to different approximations suggesting that one should not take them too seriously.

In any case, the modulus is not constant as function of p^k . For small values of p^k the envelope of the curve decreases and seems to approach constant for large values of p^k (one has x < 15 $(e^{15} \simeq 3.3 \times 10^6)$).

2. According to the first graph |F(x)| decreases for x = klog(p) < 8, is largest for small primes, and remains below a fixed maximum for 8 < x < 15. According to the second graph the amplitude decreases for powers of a given prime (say p = 2). Clearly, the small primes and their powers have much larger |F(x)| than large primes.

There are many possible reasons for this behavior. Most plausible reason is that the sums involved converge slowly and the approximation used is not good. The inclusion of only 10^4 zeros would show the positions of peaks but would not allow reliable estimate for their intensities.

- 1. The distribution of zeros could be such that for small primes and their powers the number of zeros is large in the set of 10^4 zeros considered. This would be the case if the distribution of zeros $y_a(p)$ is fractal and gets "thinner" with p so that the number of contributing zeros scales down with p as a power of p, say 1/p, as suggested by the envelope in the first figure.
- 2. The infinite sum, which should vanish, converges only very slowly to zero. Consider the contribution $\Delta F(p^k, p_1)$ of zeros not belonging to the class $p_1 \neq p$ to $F(x = log(p^k)) = \sum_{p_i} \Delta F(p^k, p_i)$, which includes also $p_i = p$. $\Delta F(p^k, p_i)$, $p \neq p_1$ should vanish in exact calculation.
 - (a) By the proposed hypothesis this contribution reads as

$$\Delta F(p, p_1) = \sum_a \cos \left[X(p^k, p_1) (M(a, p_1) + \frac{r(p_1)}{m(p_1)}) 2\pi) \right] .$$

$$X(p^k, p_1) = \frac{\log(p^k)}{\log(p_1)} .$$

Here a labels the zeros associated with p_1 . If p^k is "approximately divisible" by p^1 in other words, $p^k \simeq np_1$, the sum over finite number of terms gives a large contribution since interference effects are small, and a large number of terms are needed to give a nearly vanishing contribution suggested by the non-stationarity of the phase. This happens in several situations.

- (b) The number $\pi(x)$ of primes smaller than x goes asymptotically like $\pi(x) \simeq x/log(x)$ and prime density approximately like $1/log(x) - 1/log(x)^2$ so that the problem is worst for the small primes. The problematic situation is encountered most often for powers p^k of small primes p near larger prime and primes p (also large) near a power of small prime (the envelope of |F(x)| seems to become constant above $x \sim 10^3$).
- (c) The worst situation is encountered for p = 2 and $p_1 = 2^k 1$ a Mersenne prime and $p_1 = 2^{2^k} + 1$, $k \le 4$ - Fermat prime. For $(p, p_1) = (2^k, M_k)$ one encounters $X(2^k, M_k) = (log(2^k)/log(2^k - 1)$ factor very near to unity for large Mersennes primes. For $(p, p_1) = (M_k, 2)$ one encounters $X(M_k, 2) = (log(2^k - 1)/log(2) \simeq k$. Examples of Mersennes and Fermats are (3, 2), (5, 2), (7, 2), (17, 2), (31, 2), (127, 2), (257, 2), ... Powers $2^k, k = 2, 3, 4, 5, 7, 8, ..$ are also problematic.
- (d) Also twin primes are problematic since in this case one has factor $X(p = p_1 + 2, p_1) = \frac{\log(p_1+2)}{\log(p_1)}$. The region of small primes contains many twin prime pairs: (3,5), (5,7), (11,13), (17,19), (29,31),....

These observations suggest that the problems might be understood as resulting from including too small number of zeros.

3. The predicted periodicity of the distribution with respect to the exponent k of p^k is not consistent with the graph for small values of prime unless the periodic m(p) for small primes is large enough. The above mentioned effects can quite well mask the periodicity. If the first graph is taken at face value for small primes, r(p)/m(p) is near zero, and m(p) is so large that the periodicity does not become manifest for small primes. For p = 2 this would require m(2) > 21 since the largest power $2^n \simeq e^{15}$ corresponds to $n \sim 21$.

To summarize, the prediction is that for zeros of zeta should divide into disjoint classes $\{y_a(p)\}$ labelled by primes such that within the class labelled by p one has $p^{iy_a(p)} = e^{(r(p)/m(p))i2\pi}$ so that has $y_a(p) = [M(a, p) + r(p)/m(p))]2\pi/log(p)$.

5.6.2 More precise view about zeros of Zeta

There is a very interesting blog post by Mumford (http://tinyurl.com/zemw27o), which leads to much more precise formulation of the idea and improved view about the Fourier transform hypothesis: the Fourier transform or its generalization must be defined for all zeros, not only the non-trivial ones and trivial zeros give a background term allowing to understand better the properties of the Fourier transform.

Mumford essentially begins from Riemann's "explicit formula" in von Mangoldt's form.

$$\sum_{p} \sum_{n \ge 1} \log(p) \delta_{p^n}(x) = 1 - \sum_{k} x^{s_k - 1} - \frac{1}{x(x^2 - 1)} ,$$

where p denotes prime and s_k a non-trivial zero of zeta. The left hand side represents the distribution associated with powers of primes. The right hand side contains sum over cosines

$$\sum_{k} x^{s_k - 1} = 2 \frac{\sum_{k} \cos(\log(x)y_k)}{x^{1/2}}$$

where y_k ithe imaginary part of non-trivial zero. Apart from the factor $x^{-1/2}$ this is just the Fourier transform over the distribution of zeros.

There is also a slowly varying term $1 - \frac{1}{x(x^2-1)}$, which has interpretation as the analog of the Fourier transform term but sum over trivial zeros of zeta at s = -2n, n > 0. The entire expression is analogous to a "Fourier transform" over the distribution of all zeros. Quasicrystal is replaced with union on 1-D quasicrystals.

Therefore the distribution for powers of primes is expressible as "Fourier transform" over the distribution of both trivial and non-trivial zeros rather than only non-trivial zeros as suggested by numerical data to which Dyson [A29] referred to (http://tinyurl.com/hjbfsuv). Trivial zeros give a slowly varying background term large for small values of argument x (poles at x = 0 and

x = 1 - note that also p = 0 and p = 1 appear effectively as primes) so that the peaks of the distribution are higher for small primes.

The question was how can one obtain this kind of delta function distribution concentrated on powers of primes from a sum over terms $cos(log(x)y_k)$ appearing in the Fourier transform of the distribution of zeros.

Consider $x = p^n$. One must get a constructive interference. Stationary phase approximation is in terms of which physicist thinks. The argument was that a destructive interference occurs for given $x = p^n$ for those zeros for which the cosine does not correspond to a real part of root of unity as one sums over such y_k : random phase approximation gives more or less zero. To get something nontrivial y_k must be proportional to $2\pi \times n(y_k)/\log(p)$ in class C(p) to which y_k belongs. If the number of these y_k :s in C(p) is infinite, one obtains delta function in good approximation by destructive interference for other values of argument x.

The guess that the number of zeros in C(p) is infinite is encouraged by the behaviors of the densities of primes one hand and zeros of zeta on the other hand. The number of primes smaller than real number x goes like

$$\pi(x) = N(primes < x) \sim \frac{x}{\log(x)}$$

in the sense of distribution. The number of zeros along critical line goes like

$$N(zeros < t) = (t/2\pi) \times \log(\frac{t}{2\pi})$$

in the same sense. If the real axis and critical line have same metric measure then one can say that the number of zeros in interval T per number of primes in interval T behaves roughly like

$$\frac{N(zeros < T)}{N(primes < T)} = \log(\frac{T}{2\pi}) \times \frac{\log(T)}{2\pi}$$

so that at the limit of $T \to \infty$ the number of zeros associated with given prime is infinite. This asymption of course makes the argument a poor man's argument only.

5.6.3 Possible relevance for TGD

What this speculative picture from the point of view of TGD?

- 1. A possible formulation for NTU for the poles of fermionic Riemann zeta $\zeta_F = \zeta(s)/\zeta(2s)$ could be as a condition that is that the exponents $p^{ks_a(p)/2} = p^{k/4}p^{iky_a(p)/2}$ exist in a number theoretically universal manner for the zeros $s_a(p)$ for given p-adic prime p and for some subset of integers k. If the proposed conditions hold true, exponent reduces $p^{k/4}e^{k(r(p/m(p))2\pi)}$ requiring that k is a multiple of 4. The number of the non-trivial generating elements of super-symplectic algebra in the monomial creating physical state would be a multiple of 4. These monomials would have real part of conformal weight -1. Conformal confinement suggests that these monomials are products of pairs of generators for which imaginary parts cancel.
- 2. Quasi-crystal property might have an application to TGD. The functions of light-like radial coordinate appearing in the generators of supersymplectic algebra could be of form r^s , s zero of zeta or rather, its imaginary part. The eigenstate property with respect to the radial scaling rd/dr is natural by radial conformal invariance.

The idea that arithmetic QFT assignable to infinite primes is behind the scenes in turn suggests light-like momenta assignable to the radial coordinate have energies with the dual spectrum $log(p^n)$. This is also suggested by the interpretation of ζ as square root of thermodynamical partition function for boson gas with momentum log(p) and analogous interpretation of ζ_F .

The two spectra would be associated with radial scalings and with light-like translations of light-cone boundary respecting the direction and light-likeness of the light-like radial vector. $log(p^n)$ spectrum would be associated with light-like momenta whereas p-adic mass scales would characterize states with thermal mass. Note that generalization of p-adic length scale hypothesis raises the scales defined by p^n to a special physical position: this might relate to ideal structure of adeles.

3. Finite measurement resolution suggests that the approximations of Fourier transforms over the distribution of zeros taking into account only a finite number of zeros might have a physical meaning. This might provide additional understand about the origins of generalized p-adic length scale hypothesis stating that primes $p \simeq p_1^k$, p_1 small prime - say Mersenne primes - have a special physical role.

Chapter 6

Comparison of TGD Inspired Theory of Consciousness with Some Other Theories of Consciousness

6.1 Introduction

This work has been inspired by two books. The first book "On intelligence" is by Jeff Hawkins. The second book "Consciousness: the science of subjectivity" is by Antti Revonsuo.

6.1.1 On Intelligence

Jeff Hawkins [L25] has developed a highly interesting and inspiring vision about neo-cortex, one of the few serious attempts to build a unified view about what brain does and how it does it. Since the key ideas of Hawkins have quantum analogs in TGD framework, there is high motivation for developing a quantum variant of this vision. The vision of Hawkins is very general in the sense that all parts of neo-cortex would run the same fundamental algorithm, which is essentially checking whether the sensory input can be interpreted in terms of standard mental images stored as memories. This process occurs at several abstraction levels and involve massive feedback. If it succeeds at all these levels the sensory input is fully understood.

TGD suggests a generalization of this process.

1. Quantum jump as a moment of consciousness and a sequence of quantum jumps inducing repeated state function reduction at the same boundary of causal diamond (CD) as self would be the basic identifications. These would define the fundamental algorithm realized in all scales defining an abstraction hierarchy. Negentropy Maximization Principle (NMP, [K80]) would be the variational principle driving this process and in optimal case lead to an experience of understanding at all levels of the scale hierarchy realized in terms of generation of negentropic entanglement. The analogy of NMP with second law suggests strongly thermodynamical analogy and p-adic thermodynamics used in particle mass calculations might be also seen as effective thermodynamics assignable to NMP.

One can imagine the analogs of temperature and various other parameters as characteristics of "thermal equilibrium" under some constraints with respect to NMP instead of second law. These would be macroscopic parameters characterising the state of consciousness, and one can easily imagine psychological counterparts of thermodynamical notions. Psychological pressure would not be a mere metaphor!

2. The anatomy of quantum jump implies alternating arrow of geometric time at the level of embedding space [K13]. This looks strange at first glance but allows to interpret the growth of syntropy introduced by Fantappie [J82] as a growth of entropy in reversed direction of

embedding space time. As a matter fact, one has actually wave function in the moduli space of CDs and in state function reductions localisation of either boundary takes place and gradually leads to the increase of the embedding space geometric time and implies the alternating arrow for this time. The state function reduction at positive energy boundary of CD has interpretation as a process leading to sensory representation accompanied by p-adic cognitive representation.

The time reversal of this process has interpretation as motor action in accordance with Libet's classical findings [J15]. This symmetry holds true in various length scales for CDs. In the same ways p-adic space-time sheets define cognitive representations and their time reversals as intentions. It seems that self model could be assigned to negentropically entangled collections of sub-CDs and negentropic entanglement would stabilize them.

A rather obvious inaccuracy in the earlier interpretation of negentropic entanglement has been corrected. The statement that negentropic entanglement corresponds to the experience of understanding (or any conscious experience) is in conflict with the basic postulate of TGD inspired theory of consciousness. The correct wording is that the *generation of negentropic entanglement* gives rise the experience of understanding and possibly some other emotionally positively colored experiences. Generation and loss of negentropic entanglement would be the key to the understanding of emotions.

- 3. One could understand the fundamental abstraction process as generation of negentropic entanglement serving as a correlate for the experience of understanding. This process creates new mental images (sub-CDs) and to longer sequences of mental images (accumulation of experience by formation of longer quantum association sequences). Abstraction process involves also reduction of measurement resolution characterizing cognitive representations defined in terms of of discrete chart maps mapping discrete set of rational points of real preferred extremals to their p-adic counterparts allowing completion to p-adic preferred extremal. The reversal of this abstraction process gives rise to improved resolution and adds details to the representation. The basic cognitive process has as its building bricks this abstraction process and its reversal.
- 4. The notion of self, which should be distinguished from a model for self, has been a continual source of worries in TGD inspired theory of consciousness [K111, K13]. Hierarchy of quantum jumps suggests that self can be identified as quantum jump and that the conscious information corresponds to the change of negentropy in quantum jump. The notion of negentropic entanglement however raises the temptation to identify self model (distinguished from self) as a property of quantum state, which consciousness certainly cannot be in TGD framework. Self representations would naturally correspond to negentropically entangled tensor products approximately invariant under quantum jump sequence. One can of course ask whether the notion of self reduced to quantum jump is needed at all.

6.1.2 Consciousness: The Science Of Subjectivity

Antti Revonsuo has written a wonderful book about consciousness with title "Consciousness: the science of subjectivity" (see http://tinyurl.com/y868klny) [J13].

- 1. Revonsuo discusses philosophical, historical, and conceptual foundations of consciousness science.
- 2. Various disorders of consciousness provide test benches for the theories of consciousness and Revonsuo discusses neuropsychological deficits of visual consciousness, neuropsychological dissociations of visual consciousness from behavior, and neuropsychological disorders of selfawareness.
- 3. If one believes (and even if one does not!) that the state of brain dictates completely the contents of consciousness, it is natural to search for the neural correlates of consciousness since brain state could indeed correlate in one-one way with certain (say cognitive and representational) aspects of consciousness. Revonsuo analysizes methods and design of a typical NCC experiment, discusses neural basis of consciousness as a state and studies on the neural basis of visual consciousness.

- 4. A lot of theories of consciousness have been proposed and Revonsuo discusses both philosophical and empirical theories of consciousness critically pointing out the basic difficulties of various approaches. Revonsuo does not discuss quantum theories of consciousness.
- 5. The last chapters are devoted to altered states of consciousness (ASC) with a discussion of dreaming and sleep, hypnosis, and higher states of consciousness. The understanding of ASCs obviously define also tests for any theory of consciouesness.

In the following I will first discuss the ideas of Hawkins and then summarize some relevant aspects of quantum TGD and TGD inspired theory of consciousness briefly in the hope that this could make representation comprehensible for the reader having no background in TGD (I hope I have achieved this). The representation involves some new elements: reduction of the old idea about motor action as time reversal of sensory perception to the anatomy of quantum jump in zero energy ontology (ZEO); interaction free measurement for photons and photons as a nondestructive reading mechanism of memories and future plans (time reversed memories) represented 4-dimensionally as negentropically entangled states approximately invariant under quantum jumps (this resolves a basic objection against identifying quantum jump as moment of consciousness) leading to the identification of analogs of imagination and internal speech as fundamental elements of cognition; and a more detailed quantum model for association and abstraction processes.

After that I compare various theories and philosophies of consciousness with TGD approach following the beautifully organized representation of Revonsuo. Also anomalies of consciousness are briefly discussed. My hope is that this comparison would make explicit that TGD based ontology of consciousness indeed circumvents the difficulties against monistic and dualistic approaches and also survives the basic objections that I have been able to invent hitherto.

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 [L31].

6.2 The Vision Of Hawkins

Jeff Hawkins has written together with Sanda Blaskeslee a very inspiring book about conscious intelligence with title "On intelligence" [L25]. What makes the book so inspiring to me is that it tries to build a holistic strongly structured vision about the functioning of neo-cortex easily generalizable outside to its original context - in my case TGD inspired theory of consciousness based on rather different basic philosophy.

6.2.1 The Philosophical Attitudes Of Hawkins

Before continuing I want to locate the vision of Hawkins to the map of theories.

- 1. Hawkins accepts functionalism stating that intelligence and maybe even consciousness are properties of organization and have nothing to with the stuff that the system is made of. This was the justification for AI people to regard brain as a primitive realization of something which can be realized much more elegantly using digital computers. Hawkins assumes that the functional structure at neuronal level determines the contents of consciousness and could therefore be seen as a materialist allowing emergence.
- 2. Hawkins does not discuss the possibility of quantum consciousness but his vision might allow also quantum formulation and in the following I will represent such a generalization.

Although Hawkins accepts functionalism, he represents excellent arguments against AI and connectionism, and computationalism in general stating brain is a computer.

1. The argument against computationalism according to AI goes as follows. The time scale of neural processing is 1 ms: this is million times longer than 1 ns: the time scale of processing in modern computers. Despite its slowness brain is able to recognize a face represented in various ways in a fraction of second. For recent day computers this is a mission impossible. Computationalistic brain should make this feat by using basic programs consisting of roughly

100 steps. Parallelism does not help as often claimed. As an analogy Hawkins mentions a task of carrying some amount of material to another side of a desert. Irrespective of how many camels are hired the task takes some minimum time determined by the maximal load carried by single camel over the desert and the distance to the other side.

2. Gradually the failure of AI was accepted, and the follower of AI was connectionism. Connectionism takes the notions of association and and standardized mental image (memory) seriously and is therefore nearer to what brain is thought to do. The possibility to complete full patterns from pieces by a non-linear algorithm seemed to give excellent hopes about progress. The dream was not fulfilled.

Pattern recognition by computers differs from what brain does in one but overall important aspect: the ability to form invariant representations is lacking. When sensory input representing the same object but from a different perspective is used, computer based pattern recognition fails. A mere shift of the spatial pattern is enough to make recognition impossible. Brain can however easily recognize the pattern seen from different perspectives, the pattern can be even deformed in wide limits. Even patterns represented using pictures, sound, and touch are recognized as same object.

3. Hawkins criticizes also the behavioristic approach assuming that contents of consciousness can be deduced by looking only the behavior. Turing's test relies formulates mathematically this behavioristic dogma. It is probably relatively easy to cheat human subject to believe that machine is conscious by using Turing test. This however does not demonstrate anything. The basic problem is that the more abstract the level of cognitive process is is, the less it shows itself in the behavior. The situation in which a person is fully conscious but completely paralyzed so that he is not able to express any thoughts via motor actions illustrates a failure of the naïve behavioristic approach.

In TGD framework it is easy to agree with Hawkins. Turing machine is a model of computer in which one implicitly takes granted the identification of experienced and geometric time, which differ in many crucial aspects as even child knows. The starting point of TGD inspired consciousness theory as a generalization of quantum measurement theory is the paradox of quantum measurement theory caused by this identification. The discretization of geometric time is also an extremely heavy idealization and I find it surprising that it has raised so little criticism. In TGD framework the behavioristic approach and the materialistic identification of contents of consciousness with the state of brain must be given up since consciousness cannot be identified as a property of quantum state since it is assigned with the quantum jump between two quantum states.

6.2.2 Basic Observations Of Hawkins

Several observations and ideas of Hawking relate to the notion of time.

- 1. Instead of computation Hawkins sees memory, recognition of familiar objects in the sensory input, and their naming as fundamental processes in neo-cortex. Nerve pulse patterns are identified as names for objects. A cognitive representation is what sensory input gives rise to, and means a decomposition of the sensory input to objects with names, analogous to a linguistic essentially linear description of the percept.
- 2. It is not only spatial patterns but temporal sequences of them which matter. At higher level of abstraction one has a sequence of patterns instead of single pattern and the representation is less detailed. Sensory inputs are this kind of temporal sequences as are also plans for motor actions resulting as a reaction to the sensory input. Here "sensory input" and "motor action" could be understood very generally: even the nerve pulse patterns arriving neuron and leaving it can be seen as "sensory inputs" and "motor actions".
- 3. Hawkins emphasizes the similarities between sensory input and motor action and one can indeed claim that they one and same thing except that they seem to proceed in opposite directions of time: bottom-up and top-down. Libet's well-known findings that the neuronal

activity begins a fraction of second earlier than conscious decision for motor action and later experiments suggesting even longer time scales might be understood in this framework. If one takes this idea seriously, one must however modify the existing beliefs about the relation between subjective time and the geometric time of physicists identified as fourth space-time dimension. Subjective time has constant arrow but this arrow might correspond to different arrow of geometric time for sensory input and motor action. This brings in mind TGD based view about time [K13] and suggests more detailed interpretation of the arrow of time as it emerges in TGD framework.

4. Hawkins sees as the basic function of neo-cortex construction of predictions based on the "understanding" of the sensory input and coded by cognitive representation. Prediction might seen also as an intention how to behave realized as a motor program defining the reaction to the sensory percept.

This general vision is very elegant. The challenge is to understand what various concepts such as memory, recognition of familiar objects, naming, and understanding do mean physically. This is far from trivial in the materialistic framework of standard physics, and one can hope that quantum TGD generalizing considerably also the quantum theory itself, could help in this challenge. In particular, p-adic physics and p-adic space-time sheets could serve as correlates for the "mind stuff", and one could see the formation of cognitive representations as a formation of padic charts about real physical systems. Sensory perception would be real, cognitive representation p-adic. In p-adic topology the decomposition to objects and discretization in a given resolution are natural so that it would be ideal to the description of cognition. Negentropic entanglement would be an excellent candidate for a correlate of understanding.

6.2.3 Invariant Representations

Hawkins emphasizes the ability of brain to recognize objects represented in very different ways as a basic distinction between brain and computers.

1. Invariant representations distinguish brain from computer. Invariant representations are abstractions. Abstraction summarizes something common to a large class of objects and gives a name for this class of objects. For instance, "living room" as a name of this kind of class is extremely economical manner to represent information in terms of a concept instead of remembering every detail of every living room one has spent some time.

So called idiot savants can have this kind of sensory memory, and are able to perform incredible memory feats, but this kind of memory is not useful unless one is an artist. An interesting question is whether animals could still possess sensory memories: this would be certainly useful gift in jungle. Another interesting question is whether cerebellum could have sensory memories not conscious-to-us and whether these could become conscious-to-us in some altered states of consciousness.

Abstraction appears also in the music experience. Ordinary listener is not able to identify the key of the music piece but this does not affect the music experience much since only the ratios of the pitches of notes of the melody matter. People with "absolute ear" can however recognize the absolute key of the music piece and regard pieces in different keys as different ones. In the standard scale used for the piano, the ratios are not quite the same in different keys but this causes troubles for people with "absolute ear".

- 2. Hawkins sees the formation of associations as an important aspect of invariant representations allowing to recognize the same object using different sensory channels. Second aspect of abstraction is the elimination of un-necessary details: kind of reduction of sensory/cognitive resolution. Some kind of averaging could be involved.
- 3. Hawkins concludes that neo-cortex is specialized to the construction invariant representations and that there is a hierarchy of increasingly abstract invariant representations assignable to sensory percepts and motor actions. All these representations are needed to achieve ideal perception but only the highest level abstractions are usually conscious-to-us. Note that in standard neuro-science framework "conscious-to-us" is synonymous to "conscious" but in

quantum TGD approach entire hierarchy of conscious entities can be imaged so that "subconscious" translates to "conscious-but-not-to-us". This distinction allows to understand many brain disorders [J13] such as being not conscious of being able to see (and other agnosias) or believing that one sees although one is cortically blind or being cortically blind but believing that one is able to see. Note that if primary visual experience is at the level of retina, cortical blindness need not mean subjectively experienced blindness.

One of the hard challenges is to identify the mechanism giving rise to invariant representations. Neural firing patterns are though to transform synaptic connections and in this manner give rise to associations. Hebb's rules define an attempt to model what happens in the process. One can also understand what abstraction could mean.

In TGD framework one can consider the generation of negentropic entanglement as a mechanism of association: negentropically entangled state defines a rule represented as a superposition of state pairs (or n-plets) such that each pair (n-tuple) represents one particular instance of the rule. Abstraction means also getting rid of insignificant details. Here one can consider some kind of averaging (kind of ensemble of mental images at quantum level) or quantum superposition of states representing same object but with different details below cognitive resolution. I have also proposed that quantum states in general are superpositions of preferred extremals which have equivalent statistical geometries meaning that various geometric correlation functions are identical for them.

6.2.4 Observations About The Structure And Functioning Of The Neocortex

The proposal of Hawkins relies heavily on the observations about the structure and functioning of the neo-cortex.

- 1. Neocortex (see http://tinyurl.com/ksoqn4) [J3] is a very thin grey layer at the top of cortex having thickness of about 3 mm and consisting of 6 layers, which according to Hawkins are functionally hierarchically ordered with layer 1 at the top representing the highest level of abstraction. Layer 4 is the layer to which inputs from distant regions of neocortex arrive and are transferred to the levels above and below it. There is a strong feedback and feedforwad between the layers.
- 2. Neo-cortex decomposes to various sensory and motor areas. In associative areas the inputs from sensory areas are combined and sent to motor areas. Sensory and motor areas in turn have hierarchical structure: for instance, visual areas consisting of sub-areas V1, ..., V5. Sensory input arrives to V1 and V1 is believed to identify from the sensory input various simple features. Higher areas identify more abstract features and sequences of them.
- 3. Hawkins emphasizes the fact that sensory perception and motor action are not simple bottomup and top-down processes. Feedback is present and can be even 10 times more massive than input. The proposed interpretation is that input to from a given layer of neo-cortex to a higher layer (from say from 3 to 2) means formation of a more abstract and less detailed representation and vice versa. This representation consists also longer sequences of basic patterns and allows easier recognition. A good example is a situation in which music piece on CD changes: at the lower level this means unexpected input. At higher level music pieces on CD form a sequences and recognition as new piece is possible. The higher level can send this prediction back to the lower level.
- 4. Neo-cortex and also cortex look the same everywhere. This suggests that all basic units of the cortex perform essentially same basic function or algorithm. This idea is elegant and far reaching and would apply to the formation of cognitive representations which would be just the identification and naming of objects of sensory percept.
- 5. This picture applies also to motor action. If one accepts that motor action is time reversal of sensory perception and leads from abstract to less abstract and more detailed, one can ask whether the feedback to less abstract levels could be interpreted as motor action at neuronal

level. A fractal structure in which sensory perception and motor action takes place in various time and length scales would suggeset this kind of view.

There are many notions which require more detailed definition. The proposed detailed model for feedback need not of course be correct as such. What matters is the existence of hierarchical structure and communications between the levels of the hierarchy. In TGD framework this hierarchy would naturally correspond to self hierarchy and hierarchy of quantum jumps within quantum jups. In zero energy ontology it has as correlates the hierarchy of space-time sheets at space-time level and that of causal diamonds within causal diamonds at the level of embedding space. Also the p-adic length scale hierarchy and hierarchy of effective Planck constants assigned with dark matter in TGD Universe relate to these hierarchies.

6.2.5 Universal Algorithm

These observations inspire Hawkins to propose for the universal algorithm run by the units of neo-cortex.

- 1. The homogenuity of neocortex motivates the proposal that all units of the neo-cortex forming a hierarchy are performing the same universal algorithm, which is recognition of the virtual sensory input represented as nerve pulse pattern with some standard input stored in memory. If the recognition attempt fails, the input is sent to a higher more abstract level with less details and this level makes a similar trial. If the recognition attempt is successful, the input is sent to a lower level (this corresponds to a feedback) and same attempt is made.
- 2. This process continues until recognition is made at all levels or if this is not possible, the pattern is sent to hippocampus as a genuinely new pattern to be stored to memory. Some maximum time of unsuccessful processing is a natural criterion for the novelty. Percept is thus stored as a memory in hippocampal level only when it represents something new. The percepts which do not enter hippocampus are stored at lower cortical layers but do not represent memories conscious-to-us. This could explain why people at older age are not able to remember details of say movie unless they represent something genuinely new.

To me this picture looks rather attractive and inspires the question whether a generalization to quantum context - say in TGD framework - is possible.

6.2.6 The Basic Objection Against The Vision Of Hawkins

The basic objection against Hawkins's vision applies to neuroscience view in general.

- 1. As Hawkins notices, the homogenuity of the neocortex and brain in general is in conflict with the idea that cortex is the seat of the sensory qualia. It is difficult to understand why the auditory and visual pathways could give rise to so different sensory qualia if only the organization of the sensory pathways matters.
- A possibility not discussed by Hawkins nor by neuroscientists is that sensory qualia could be formed at the level of sensory organs.
 - (a) TGD approach would suggest that qualia are realized at the level of sensory organs [K59] and quale mental images (sub-selves) entangle with the cortical mental images representing names of objects of the perceptive field represented at cortex and thus give rise to a coloring of the cognitive map. This would explain why the qualia associated with different sensory pathways are so different. Pure thought would correspond to cognition without this coloring and dreams would involve a feedback to the level of sensory organs (REM sleep) transforming thinking to vivid imagination. Note that also the feedback to the level of sensory organs and comparison of this virtual sensory input with the actual one is quite possible in TGD framework since there is no reason to restrict the feedback hierarchy to the 6 neo-cortical layers. Dark photons with large value of \hbar_{eff} could make possible this feedback by generating sensory input by transforming to ordinary visible photons interpreted as bio-photons.

(b) The basic objection against this view is the phenomenon of phanton limb (see http: //tinyurl.com/5gvftz) [J38], which in standard physics framework forces to locate the pain to the map of sensory field at cortex. One manner to solve the problem would be that that the pain is somewhere else than in phantom limb but mislocated in the construction of cognitive representation: this would be just wrong kind of association. The alternative approach would give up the standard view about the relationship between subjective and geometric time: the phantom pain is sensory memory of an actual pain in the limb which exists in the geometric past at a distance of maybe decades. The third option is that qualia are formed at the level of neurons and under some conditions correspond to those experienced by us. This requires new physics at the level of neurons and clear identification what the physical correlates of qualia are in this new physics.

6.3 Quantum TGD Very Briefly

Before discussing the TGD inspired identification of the universal algorithm as quantum jump in turn identified as a moment of consciousness, it is good to briefly summarize some basic aspects of quantum TGD.

6.3.1 Many-Sheeted Space-Time, Embedding Space, WCW

The basic geometric notions of TGD are many-sheeted space-time (see Fig. http://tgdtheory. fi/appfigures/manysheeted.jpg or Fig. 9 in the appendix of this book), embedding space $M^4 \times CP_2$ (see Fig. ?? in the appendix of this book) and "world of classical worlds" (WCW) identified as the infinite-dimensional space of space-time surfaces, which can be seen as analogs of Bohr orbits representing kind of archetypal field patterns in their geometry. The choice of the embedding space is fixed by particle physics considerations uniquely and can be justified also by very general mathematical arguments. For instance, M^4 is the only space with Minkowskian signature allowing twistor structure, and CP_2 is one of the very few Euclidian compact manifolds allowing twistor structure and the only one for which twistor space is Kähler manifold. TGD leads to geometrization of the classical fields appearing in standard model and particle quantum numbers can be understood in terms of the symmetries of the embedding space.

I will not go the detailed definitions of these notions here but refer to the articles and books at my homepage. What is essential is that TGD space-time is topologically non-trivial in all length scales and objects of various size scales that we see around us can be interpreted in terms of space-time sheets defining their own sub-Universes.

Second essential generalization and deviation from Maxwell's electrodynamics (and other field theories) is topological field quantization. For instance, magnetic field decomposes to flux quanta (flux tubes and sheets) represented as space-time time quanta. This quantization is in key role in the model of living matter and the dynamics of the "magnetic bodies" is crucial for understanding various aspects of bio-catalysis and also EEG. Magnetic body (hierarchy of them) brings to the usual picture of living system as biological body interacting with environment a completely new level.

6.3.2 Zero Energy Ontology (ZEO)

The failure of the strict determinism for the preferred extremals of Kähler action means that data in time=constant snapshot do not determine the future and past behavior. Several time=constant snapshots must be assumed and this led originally to the notion of association sequence. Later the notion of zero energy ontology (ZEO) emerged and was forced by number theoretical universality: the vanishing total quantum numbers indeed make sense in number theoretically universal manner. ZEO allows also to avoid the paradox suggested by the fact that Poincare invariance is exact in laboratory scales but not in cosmological scales: the solution relies on the observation that the notions of energy and momentum for the positive energy parts of zero energy states are scaled dependent in ZEO.

1. Zero energy states are superpositions over pairs of positive energy states and negative energy states and correspond to initial and final states of a physical event in positive energy ontology.

Positive and negative energy states are localized at the opposite light-like boundaries of a causal diamond (CD) defined as intersection of future and past directed light-cones (CP_2 appears as a Cartesian factor but will not be mentioned separetely in the sequel). Space-time surfaces in the quantum superposition are identified as preferred extremals of Kähler action and are restricted inside CD for the simplest option.

- 2. CDs form a fractal hierarchy with size scales coming as integer multiples of fundamental size scale. Translates and Lorentz boosts of CDs are also possible. It is not quite clear whether one should allow CDs to intersect or should one require strict nesting. System has in general wave function in the moduli space of CDs and in quantum jump a localization to CDs for which either upper or lower boundary is fixed takes place.
- 3. CDs are the geometric correlates of selves at the level of embedding space $M^4 \times CP_2$. The 4-D space-time surfaces define the correlate of selves at space-time level. One can consider two time coordinates: embedding space time coordinate and that of 4-D surface.

6.3.3 P-Adic Physics And Cognition

I ended up with p-adic physics from accidental observations related to the mass scale ratios of elementary particle spectrum. The construction of p-adic thermodynamics predicting particle masses with excellent accuracy inspired questions which led to the proposal that p-adic physics describes cognition present already at elementary particle level.

1. Embedding space has also p-adic sectors corresponds to various p-adic number fields. These sectors are glued together along rational points common to real and p-adic number fields and also via common algebraic points in the case of algebraic extensions of p-adic number fields. The common rational points of real and p-adic space-time surface (or at least partonic 2-surface) define cognitive representation so that cognitive representations are always discrete.

At the level of WCW the points of real and p-adic sectors identifiable with each other correspond to surfaces, whose algebraic representations make sense both in real and p-adic sense. The general vision is that life resides in this this intersection of real and p-adic worlds. For instance, this motivates the notion of number theoretic entanglement entropy which can be negative and is interpreted as a measure of information assignable to entanglement.

- 2. Mappings of real space-time surfaces to p-adic ones are fundamental and define cognitive representations [K145]. The mappings of p-adic space-time surfaces to real ones are interpreted as realizations of intentional actions. When motor action is identified as the time reversal for the formation of sensory representation, intentional action becomes time reversal for the formation of cognitive representation so that a very powerful and elegant symmetry emerges.
- 3. Finite measurement resolution is fundamental notion and actually forced by the notion of p-adic manifold. An attractive additional constraint is that the space-time surfaces in the superposition are perceptively equivalent in given measurement resolution characterized by p-adic prime assignable to the space-time surface and corresponding pinary cutoffs and also by the algebraic extension of p-adic numbers characterizing the angle resolution.

6.3.4 Length Scale Hierarchies And Cognitive Hierarchies

TGD involves several hierarchies.

- 1. One hierarchy is formed by the p-adic length scales assignable to p-adic primes coming as primes near powers of two.
- 2. Second hierarchy corresponds to size scales of CDs coming as integer multiples of CP_2 scale with secondary p-adic length scales being favored. One can assign to these length scales length scale resolution as p-adic length scale multiplied by a half-integer power of p, and angle resolution defined in terms of algebraic extension of p-adic numbers used. These length scales are now an essential part of the definition of the notion of p-adic manifold necessary for the construction of number theoretically universal calculus.

The resolution scales have also natural counterpart at quantum level and can be realized in terms of inclusions of hyper-finite factors of type II_1 [K143]. The included factor defines the degrees of freedom which cannot be seen in given resolution and the factor space obtained by dividing with the included factor defines quantum space with finite but fractional dimension.

- 3. The increase of resolution means getting rid of un-necessary details in the case of cognitive representations it would be un-necessary information allowing a formation of abstraction. The reduction of the resolution means addition of details and formation of lower level representation. In the realization of motor action this process indeed occurs. This process can be however as a formation of sensory representation in non-standard time direction. The findings of Libet conform with this view about motor action.
- 4. The hierarchy of (effective) Planck constants \hbar_{eff} was conjectured for about 8 years ago [K55].
 - (a) The values of \hbar_{eff} would come as multiples of ordinary Planck constant: $\hbar_{eff} = n\hbar$. TGD provides two possible explanations for how \hbar_{eff} emerges. The first one relies on multi-furcations of space-time surface implied by the failure of strict determinism of the basic variational principle: $\hbar_{eff} = n\hbar$ would correspond to *n*-furcation taking place at the boundary of causal diamond. Second explanation relies on the general structure of p-adic Lie-algebras predicting effective values of Planck constant coming in the proposed manner [K145]. These explanations should and could be equivalent.
 - (b) For large values of \hbar_{eff} the quantal scales (say Compton length of electron) become large and this makes possible macroscopic quantum coherence. The hypothesis is that dark matter corresponds to ordinary matter but with non-trivial value of \hbar_{eff} . What would make it dark is that particles with different values of \hbar_{eff} cannot occur in the same vertex of a generalized Feynman diagram although particles with different value of \hbar_{eff} can transform to each other.
 - (c) The proposal is that magnetic flux quanta (sheets and tubes) can be carriers of dark matter. The phase transitions reducing \hbar_{eff} reduce the length of the magnetic flux tube and if biomolecules form an "Indra's net" connected by flux tubes, these phase transitions could force two biomolecules connected by flux tube near to each other so that they could find each other in the dense molecular soup. The reconnection of closed magnetic flux tubes associated with two molecules in turn generates two flux tube pairs connecting the molecules and allowing the two systems to become effectively single quantum system in dark degrees of freedom with large value of Planck constant. Persinger's recent experiments give support for this vision [L28].

6.4 Quantum Jump As The Counterpart Of Fundamental Algorithm In TGD?

In order to formulate the interpretation of quantum jump sequence as a fundamental algoritm of sensory perception, cognition, intentional action, and motor action, one must describe the basic ideas of TGD inspired theory of consciousness.

6.4.1 Basic Ideas Of TGD Inspired Theory Of Consciousness

Before discussing the TGD based analog for universal algorithm, it is good to begin by giving a list about basic ideas of TGD inspired theory of consciousness.

1. Identification of quantum jump between zero energy states as moment of consciousness. It is essential that the quantum states counterparts for entire time evolutions of Schrödinger equation rather than time=constant snapshots of single evolution. In this manner one can avoid the conflict between non-determinism of state function reduction and determinism of Schrödinger equation. This however implies that subjective time, whose chronon quantum jump is, cannot be identified with the geometric time of physicists. The correlation between these two times is of course possible in the sense that quantum jump sequences corresponds to an increase of geometric time defined in some natural manner. This correlation must be strong since these two times are usually identified.

2. Originally I distinguished between the notions of quantum jump and self proposed to emerge from some kind of gluing together of quantum jumps to larger structures in a manner analogous to the fusion of particles to bound states. The fractality of quantum jump in the sense that there are quantum jumps within quantum jumps led to the identification of quantum jump and self. This identification has however remained somewhat fuzzy.

The recent considerations however suggests that negentropic entanglement in time direction is necessary for mental images (having sub-CDs as correlates) to mental images representing spatial patterns and for these patterns in turn to bind to a sequence of mental images representing abstract memories as sequences of mental images. Negentropically entangled sequence would be a quantal counterpart for the original association sequence introduced as purely geometric concept.

Should these sequences define selves so that self would be something characterizing quantum state rather than something identified as quantum jump? Or could these sequences define a model of self to be distinguished from self identified as quantum jump? By definition negentropic entanglement (see Fig. http://tgdtheory.fi/appfigures/cat.jpg or Fig. ?? in the appendix of this book) tends to be preserved in quantum jumps so that it represents information as approximate invariant: this conforms with the idea of invariant representation and quite generally with the idea that invariants represent the useful information. This information would not be however conscious if the original view about conscious information as change of information is accepted. Could one imagine a reading mechanism in which this information is read without changing the negentropically entangled state at all? This reading process would be analogous to deducing the state of a two-state system in interaction free measurement to be discussed below.

- 3. Selves form a hierarchy, which predicts higher level selves identifiable in terms of collective and transpersonal consciousness. Also lower levels of hierarchy should be present so that even neuron and even electron should possess primitive self-awareness.
- 4. The sub-selves of self are identified as mental images of self and sub-sub-selves are assumed to be experienced as ensemble averages- at least when the entanglement is not negentropic. This averaging could be seen as an alternative mechanism for the formation of abstractions. Another mechanism would be based on quantum superposition of perceptively equivalent space-time surfaces. Sharing of mental images by entanglement of sub-selves is proposed and the motivation comes from the space-time correlates of entanglement identified as magnetic flux tubes connecting the space-time sheets of sub-selves although space-time sheets of selves are disjoint. This picture requires a generalization of the usual tensor product description for the formation of many-particle states.

Negentropy Maximization Principle (NMP) defines the basic variational principle of TGD inspired theory of consciousness.

- 1. NMP states that the negentropy gain in the quantum jump is maximal. For the ordinary entanglement entropy NMP implies that state function reduction leads to a pure state, which is an eigenstate of the density matrix characterizing the interaction of subsystem with its environment. An interesting purely mathematical result is that the assumption that density matrix always reduces to a partial trace of pure state density matrix leads to the basic rules of quantum theory probabilities. TGD inspired theory of consciousness, which can be seen as a generalization of quantum measurement theory, allows only this kind of density matrices.
- 2. If one accepts the notion of negentropic entanglement, number theoretic entropy can become negative in state function reduction. This makes possible formation of negentropically entangled states whereas in the usual state function reduction entanglement is always reduced. Negentropy is however associated with the entanglement rather that single particle states of either particle so that no problems with second law emerge.

Consistency with quantum measurement theory forces to assume that the density matrix of the final state is projector, which can be higher than 1-dimensional. This allows to identify negentropic entanglement uniquely: in the general case it would be impossible to tell in practice whether entanglement is negentropic.

A further refinement to NMP is what I call weak NMP. It does not force the best possible outcome. Self has freedom to project also to the lower-dimensional sub-space. This has several interesting consequences, mention only the possibility to say something interesting about the physical correlates of ethics and moral and origin of emotional intelligence [K139], and also about the origin of p-adic length scale hypothesis [K142].

3. NMP and second law are structurally very similar and one can consider the notion of the counterpart of thermodynamical equilibrium in which the average values of some conserved quantities are fixed so that one can assign to them temperature like parameters. At least in the ideal situation quantum jump could lead to the analog of thermal equilibrium prevailing in all scales with maximum amount of negentropic entanglement. This is probably too strong an idealization. The assignment of the experience of understanding with the generation of negentropic entanglement is a highly attractive idea. To assign it with negentropic entanglement itself does not conform with the basic postulate.

Both p-adic length scales and CDs form a hierarchy and this raises the question whether or not the quantum jumps inside CDs within CDs are related or not. One can consider three options.

- 1. For the first option the cascade of state function reductions can begin from any *unentangled* CD and after that proceeds to shorter length scales (smaller sub-CDs) until it stops when maximally negentropic entanglement is reached. This cascade would be analogous to motor action proceeding from long to short scales as detailes of the motor action are fixed. For sensory perception the cascade would be same but in opposite direction of embedding space geometric time (state function reduction for the opposite boundary of CD). This would imply an effect analogous to quantum Zeno effect. If for given CD quantum jump cascade can begin only if CD is unentangled, negentropic entanglement stabilizes the CD, and it can spend long times in this negentropically entangled state but would not be conscious.
- 2. One can consider also the possibility that the CD from which the cascade begins is entangled with other CDs so that in quantum superposition of states the state function reduction cascades could occur separately for all summands. This would mean quantum parallelism for state function reductions. What is essential that state function reductions for components of the linear superposition in a given scale can occur only in shorter scales. For instance, in this picture hadrons could be seen as quantum coherent structures in hadronic length scales but dissipative quantum structures in quark length scales. It is not clear to me whether the possible non-uniqueness of the state basis could exclude quantum parallellism for state function reductions.
- 3. For the third option quantum jumps inside various CDs would occur independently and top-down and bottom-up cascades are not predicted.

6.4.2 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, fourmomentum, 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 [K85]: 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 boots 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 [J82] 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 though. 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 - adele- with an algebraic extension of rationals as its back. Same applieds at the level of embedding space, space-time surfaces, and WCW. In this framedwork 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 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 $h_{eff} = n \times h$ 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 mazimal negentropy gain and would mean best possible world.ur in various length scales in fractal manner.

6.4.3 How Memories Are Represented And Recalled?

Formation of memories and memory recall are key elements in the vision proposed by Hawkins. The question is what memories and memory recall are. If quantum jump is the fundamental process, it should automatically give rise to memories and memory recall.

- 1. Memories in given scale would naturally correspond to sequences of mental images defined by negentropically entangled sub-CDs of CD in given scale. According to earlier view the sequences of moments of consciousness bind to form higher level moments of consciousness, selves. Somewhat different view is that formation of selves means formation of sequence of negentropically entangled sub-CDs stable against NMP and preserved in quantum jump and even increasing in size. Thus self would correspond to a property of state and consciousness would be associated with the replacement of state with a new one.
- 2. The hierarchical structure of memories would emerge naturally. Conscious memory recall would correspond to a generation of negentropic entanglement between the new mental images emerging in the state function reduction (recall that the sizes of CDs increase and new sub-CDs emerge) and already existing negentropically entangled mental images. Generation of negentropic entanglement would give rise to the experience of recognition of the new mental images.

3. The natural guess is that negentropic entanglement is generated if the new sensory input is "consistent" with older mental images. The addition of new tensor factor would mean a more abstract representation so that the sequence of quantum jumps would mean accumulation of experience. Consistency with older mental images could mean that the mental images have same "name". The name could correspond to p-adic cognitive representation. The physical correlate could be a collection of resonance frequencies. The names would be same if the frequencies for older mental images and new one are same, so that resonant interactions becomes possible. The generation of negentropic entanglement would be like finding a radio station.

For this proposal memory recall and memory formation are actually more or less the same thing. Only the completely new memories claimed to be formed in hippocampus would not involve memory recall. The new memory would correspond to a new sub-CD or ensemble of sub-CDs representing the associated negentropically entangled mental images. Neuronal loop could make possible to build copies about the new memory and thinking about it would create copies of corresponding p-adic cognitive representations which in turn could be transformed via state function reduction to an opposite boundary of CD to actions. In TGD framework the 4-D hierarchy of memories could continue from hippocampus to the magnetic body: this would explain the correlation of EEG with memory and also with various other brain functions.

6.4.4 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 zero energy state resulting in the reduction for given CD would generalize this hypothesis. If this assumption hold true, the subsequent reductions at the same boundary of CD would effectively correspond to single reduction 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. 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 cyclity 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.

6.4.5 Self Or Only A Model Of Self?

Negentropic entanglement provides a model for associations as rules in which superposition of tensor product states defines rule with entanglement pairs defining its various instances. This generalizes to N-fold tensor products. Associations would be realized as N-neuron negentropic entanglement stable against NMP. One could also think of realizing associative areas in terms of neurons whose inputs form entangled tensor product and when sensory inputs are received they form analogous tensor product in representative degrees of freedom.

Thus negentropic entanglement is necessary for mental images (having sub-CDs as correlates) to mental images representing spatial patterns. Negentropic entanglement in time direction for these patterns (zero energy states) is in turn necessary to bind them to sequences of mental images representing abstract memories as sequences of mental images. Negentropically entangled sequence would be a quantal counterpart for the original association sequence introduced as purely geometric concept.

This picture however challenges the identification of self as quantum jump. Should the negentropically entangled sequences of mental images define selves so that self would be something characterizing zero energy state rather than something identified as quantum jump? Could they define a model of self to be distinguished from self identified as quantum jump? Or could one give up the notion of self altogether and be satisfied with model of self? At this moment it seems that nothing is lost by assuming only the model of self.

By definition negentropic entanglement tends to be preserved in quantum jumps so that it represents information as approximate invariant: this conforms with the idea of invariant representation and quite generally with the idea that invariants represent the useful information. There is however a problem involved. This information would not be conscious if the original view about conscious information as a change of information is accepted.

Could one imagine a reading mechanism in which this information is read without changing the negentropically entangled state at all? This reading process would be analogous to deducing the state of a two-state system in interaction free measurement to be discussed below in more detail. If has turned out that the original proposal that interaction free measurement could allow to achieve this does not work. Indeed, the recent formulation of TGD inspired theory as quantum measurement theory in Zero Energy Ontology and assuming NMP requires that negentropic entanglement assignable to the passive boundary of causal diamond (CD) is directly experienced and defines what might be called unchanging self.

The interaction free measurement could however allow to read memory representations constructed in terms of bits without changing them at all at idealized limit and for this reason is discussed below.

6.4.6 Could Interaction Free Measurement Be Used To Read Memory Representations?

If memory representations are realized in terms of bits, there should exists a way to read them without changing them. No-cloning theorem prevents this but one can imagine a reading mechanism inducing no changes at idealized limit. The following proposal for non-destructive reading of memories and future plans allows to resolve this problem.

Bomb testing problem as a model for interaction free measurement

One can consider a generalization of so called interaction free measurement as a way to deduce information about self model realized in terms of bits at active boundary of CD. This information would be obtained as sequences of bits and might be correspond to declarative, verbal memories rather than direct sensory experiences.

1. The bomb testing problem of Elitzur and Vaidman gives a nice concrete description of what happens in interaction free measurement, see http://tinyurl.com/kx2jsyu [B2] for an illustration of the system considered.

The challenge is to find whether the bomb is dud or not. Bomb explodes if it receives photon with given energy. The simplest test would explode all bombs. Interaction free measurement allows to make test by destroying only small number of bombs and at idealized limit no bombs are destroyed.

The system involves four lenses arranged in square and two detectors C and D at the upper right corner of the square. In the first lense at the lower left corner the incoming photon beam splits to reflected and transmitted beams: the path travelled by transmitted beam contains the bomb.

- (a) The bomb absorbs photon with a probability which tells the fraction of photon beam going to the path at which bomb is (is transmitted through the lense). The other possibility is that this measurement process creates a state in which photon travels along the other path (is reflected). This photon goes through a lense and ends up to detector C or D through lense.
- (b) If the bomb is dud, the photon travels through both paths and interference at the lense leads the photon to detector D. If C detects photon we know that the bomb was not a dud without exploding it. If D detects the photon, it was either dud or not and we can repeat the experiment as long as bomb explodes, or C detects photon and stop if the detector continues to be D (dud). This arrangement can be refined so that at the ideal limit no explosions take place and all.
- 2. The measurement of bomb property is interaction free experiment in the sense that state function reduction performed by absorber/bomb can eliminate the interaction in the sense that photon travels along the path not containing the bomb. One might say that state function reduction is an interaction which can eliminates the usual interaction with photon beam. State function reduction performed by bomb can change the history of photon so it travels along the path not containing the bomb.

This picture is only metaphorical representation of something much more general.

- 1. Bomb could be of course replaced with any two-state system absorbing photons in one state but not in the other state, say atom. Now one would test in which state the atom is gaining one bit of information in the optimal situation. Two-state atom could thus represent bit and one could in principle read the bit sequence formed by atoms (say in row) by this method without any photon absorption so that the row of atoms would remain in the original state.
- 2. Two-state system could be replaced with N-state system. In this case the testing selects at first step one state as analogs of bomb intact and the remaining states as analogs of dud. If the answer was "dud" in the first step, the next step selects one preferred state from N-1 states and regards the remaining states as "dud". The process continues until the state of the system is measured.

3. In TGD framework the photon paths branching at lenses correspond to branching 3-surfaces analogous to branching strings in string model and photon wave splits to sum of waves travelling along the two paths.

Memory recall as an interaction free measurement

One can imagine several applications if the information to be read in interaction free manner can be interpreted as bit sequences represented as states of two-state system. Lasers in ground states and its excited state would be analogous many particle quantum system. In TGD framework the analog of laser consisting of two space-time sheets with different sizes and different zero point kinetic energies would be the analogous system.

For instance, a model of memory recall with memories realized as negentropically entangled states such that each state represents a bit can be considered. The model applies also to the reading of future plans (memories on reversed time direction).

- 1. Reading of a particular bit of memory means sending of negative energy photon signal to the past, which can be absorbed in the reading process. The problem is however that the memory representation is changed in this process since two state system returns to the ground state. This could be seen as analog of no-cloning theorem (the read thoughts define the clone). Interaction free measurement could help to overcome the problem partially. Memory would not be affected at all at the limit so that no-cloning theorem would be circumvented at this limit. Memory bit to be read would be mathematically analogous to bomb in the Elizur-Weizman bomb tester thought experiment in which one tries to determine whether bomb is active (bit 1) and can therefore explode or passive (bit 0) and cannot explode.
- 2. A possible problem is that the analogs of detectors C and D for a given bit are in geometric past and one must be able to decide whether it was C or D that absorbed the negative energy photon! Direct conscious experience should tell whether the detector C or D fired: could this experience correspond to visual quale black/white and more generally to a pair of complementary colors?
- 3. ZEO means that zero energy states appear have both embedding space arrows of time and these arrows appear alternately during periods of repeated state functions having no effect at the other boundary of CD. This dichotomy would correspond to sensory representationmotor action dichotomy and would suggest that there is no fundamental difference between memory recall and future prediction by self model and only the time direction of the signal differs for them.
- 4. Since photon absorption is the basic process, the conscious experience about the bit pattern could be visual sensation or even some other kind of sensory qualia induced by the absorption of photons. The model for the lipids of cell membrane as pixels of a sensory screen suggests that neuronal/cell membranes could serve defined digital self model at the length scale of neurons.
- 5. Active/passive dichotomy can be represented in very simple manner physically. One has two state system in which lower energy state can be excited to a long lived higher energy state by photon absorption. System in higher energy state is passive and that in lower energy state active.

Some comments are in order.

1. To avoid misunderstandings it should be emphasized that TGD based view about memory is not the same as the standard view. In ZEO brain is four-dimensional and in principle memories can be negentropically entanglement memories in geometric past. It is possible to build copies of memories by memory recall, and learning would correspond to a generation of large enough number of copies of the memory mental image. Memory recall could be seen as a negative energy signal inducing the interaction free measurement of memory bits. Dark photons with EEG frequencies (say in theta band characterizing hippocompus) but having energies of visible photons could be involved with the memory recall. Correlation between EEG and bio-photons supports this view. 2. If the systems taking the role of the detectors C and D in interaction free measurement are analogous to population reversed lasers, their return to the ground state could automatically generate virtual sensory input propagating to the sensory organs and allowing to check whether it is consistent with the actual sensory input. The generation of the feedback signal takes some time expected however to be much shorter than that for a typical neuronal activity.

Since the signals would propagate with light velocity, the virtual sensory input could travel practically instantaneously from the brain to sensory organs and possibly also vice versa. Libet's experiments on passive aspects of consciousness [J42] in fact demonstrate a time delay which is fraction of second having interpretation in terms of time to propagate to a layer of magnetic body of size scale of Earth and back: these delays are consistent with the fact that the chronon of sensory experience is about.1 seconds. The propagation of photon signals in both directions would make possible construction of sensory representation in time scale much shorter than that of neural activity. This mechanism could also explain generation of after images.

3. Photons can be replaced with phonons or quanta of any other wave motion with constant propagation velocity (no dispersion of signal) in a given reference frame. This suggests that imagination and internal speech correspond to the two reading mechanisms of memories.

Some critical questions

There are two basic objections against quantum theories of consciousness. How it is possible to have conscious information about invariant under quantum jumps if only change is experienced continuously? The outcome of state function reduction in standard quantum theory is random: how can one understand freedom of choice and intentional behaviour in terms of state function reduction? NMP and the possibility of negentropic entanglement imply that TGD based quantum theory is not equivalent with the standard one, and this allows to circumvent the objections.

The experiments carried out to test whether 40 Hz thalamocortical resonance is correlate for conscious experience suggests that the resonance is present only when a new pattern is discovered, not when it has become a memory. The TGD inspired interpretation would be that the resonances accompanies negentropy gain and quantum jump is necessary for conscious experience. However, the reports about higher states of consciousness (and also my own experiences) suggest that the invariants can be experienced directly when all thoughts (interaction free measurements) are eliminated. This experience cannot be however communicated: one understands does not know what one understands. Therefore also the original vision that negentropic entanglement corresponds to conscious experience - experience of pure understanding, which is not communicable - and in apparent contradiction with the basic hypothesis about quantum jump, would be correct after all!

Why vision and hearing are so fundamental for cognition?

The interaction free measurement is formulated in terms of photons. It can be however formulated also for sound waves using phonon detectors and acoustic waves traversing through two different paths. Quantum coherence is required but the hierarchy of Planck constants makes sense also for phonons by the basic equation E = hf.

In TGD framework there are good reasons to believe that sound waves are not only something emerging at the level of condensed matter but correspond to oscillations of string like objects at 4-D space-time surface. These strings connect the wormhole contacts assignable to the light-like orbits of partonic 2-surfaces. Partonic 2-surfaces can be assigned with elementary particles but also to 2-surfaces with arbitrarily large size scale. The outer boundary of any physical object would correspond to a partonic 2-surface. String world sheets carry fermion fields localized at them (right-handed neutrino is an exception in that it is de-localized at entire space-time surface). The fact that strings always connect two partonic 2-surfaces corresponds to the fundamental twoparticle character of sound waves. Sound would be as fundamental phenomenon as photons and other massless bosons.

This encourages to ask whether photon (more generally gauge boson: TGD suggests that scaled up copies of gluons and weak bosons behaving like massless particles even in cell length scale are possible) and photon absorption could define fundamental memory representations of information realized in terms of interaction free measurements.

Photons would correspond to "seeing" but at neuronal level rather than at the level of retina - and imagination. Phonons would correspond to hearing at neuronal level and internal speech which is also essential for cognition. Both internal speech and imagination could be understood at fundamental aspects of cognition. Dark photons with energies of visible photons (decaying to what is interpreted as bio-photons) and dark phonons would be behind imagination and internal speech. I have already earlier proposed that the lipid layers of neuronal membranes (and maybe also ordinary cell membranes) can be regarded as pixels of a sensory map representing neuronal qualia [K59]. These pixels could serve as the counterparts of the detectors C and D appearing in interaction free measurement. The evidence for the importance of bio-photons (in TGD framework dark photons decay to bio-photons in energy conserving manner) in biology and neuroscience is emerging, see for instance the experiments of Persinger's group [J48, J49, J50]. I have discussed these findings from TGD point of view in [L28].

One can speculate about direct translation between the words of language and visual preimages. In general I try to avoid reference to anything personal since but at this time I cannot resists the temptation to mention that during my first "great experience", which served as a powerful inspiration for TGD inspired theory of consciousness, I was able to see my thoughts and discovered that this kind of correspondence seems to exists: I did experimentation with internal speech by uttering words and immediately getting visual image to my visual field as a response!

Biophotons seem to be associated only with the right hemisphere [J48]. This suggests that right hemisphere or some parts of it prefer dark photons being thus specialized to visual imagination in accordance with the fact that spatial relationships are the speciality of the right hemisphere. Could this mean that left hemisphere or some parts of it prefer dark phonons (or dark photons in IR range transforming [L28] to ordinary photons at ear and generating virtual auditory input? Left hemisphere indeed is the verbal hemisphere specialized to linear linguistic cognition and produces also internal speech.

Realization of memory representations in terms of braided flux tubes

While reading a marvellous book "The Field" by Lynn McTaggart [I101] about evolution of ideas about the role of electromagnetic fields in biology and neuroscience, I became aware of two questions which I had not yet answered. The first question is following: How various representations (sensory -, memory -, ...) - "Akashic records" - are realized as negentropically entangled states?

Magnetic body should be the seat of memories in some sense.

- 1. I have already earlier proposed this kind of realization based on the observation that braiding in time direction generates space-like braiding [K6]. Dancers on the parquette with their feet connected to the wall by threads illustrates the idea. When dancers move at the parquette their world lines define a time-like braiding in 3-dimensional space-time assignable to the floor. Also the threads connecting the dancers to the wall get braided - or entangled - as one might also say. There is clearly a duality between time-like and space-like braidings: the running topological quantum computer program coded by braiding in time direction is stored as space-like braiding defining memory representation of what happened. Note that same mechanism realizes also predictions and future plans as time reversed topological quantum computer programs in ZEO. CDs in various scales contain this kind of programs and their memory representations.
- 2. I have also proposed that the geometric entanglement braiding of flux tubes defines a spacetime correlate for quantum entanglement. In the case of topological quantum computation it would be naturally described by probabilities, which are rational numbers (or perhaps even algebraic numbers in some algebraic extension of p-adic numbers characterizing together value of the p-adic prime the evolutionary level of the system). Hence the notion of number theoretic negentropy makes sense and one obtains a connection with topological quantum computation.
- 3. The representation of memories in terms of space-like braiding of magnetic flux tubes connecting various systems would be universal, and not restricted to DNA-cell membrane system

in which the flux tubes would connect DNA nucleotides [K6, K138] or codons (this seems to be the more plausible option [L28]) with the lipids. One could indeed speak about Akashic records (see http://tinyurl.com/5hxjpr).

4. The time reversals or these representations defined by the zero energy states of opposite arrow of the embedding space time would define a representation for future predictions/ plans in ZEO. For instance, the development of a seed to a full-grown organism could be coded in this manner in time scale where CD has time scale of order of the lifetime of the organism. Already Burr found evidence that the radiation field assignable to the seed has the same shape as the plant [I91, I101] or animal (salamander in his experiments). This energy field would naturally correspond to the magnetic body containing dark photon Bose-Einstein condensates. The Akashic records and their time reversal would naturally correspond to the morphic fields of Sheldrake [L19, I120]: memories and future plans in time scales longer than than duration of life cycle for an individual member of species would be possibles. Every scientist of course agrees that the societies are busily predicting and planning their futures but find very difficult to accept the idea that this could have some concrete quantum physical correlate.

How to construct and read conscious hologram?

The above discussion raises the question about how the vision about brain as a conscious hologram is realized in the proposed conceptual framework.

The idea about living system as a hologram has strong empirical basis. One of the most dramatic demonstrations of the hologram like character of brain was the discovery of Pietch [J94] that salamander's brain can be sliced to pieces and shuffled like a deck of cards and put together. When the resulting stuff is returned to the head of the salamander, it recovers! This extreme robustness is very strong support for the non-local hologram like storage of biological information. Ironically, Pietch tried to demonstrate that the theory of Karl Pribram [J80, J81] about brain as a hologram is wrong! In TGD framework one can go even further and ask whether this robustness actually demonstrates that various representations (sensory - , cognitive -, memory -...) are realized at the long magnetic flux loops and sheets of the magnetic body rather than brain.

The notion of conscious hologram [K24] is one of the key ideas of TGD inspired theory of consciousness. Hitherto I have not been however able to find a really convincing concrete proposal for how brain could be a hologram in TGD Universe. The reading of memory - and other representations by interaction free measurement however leads to a natural proposal for what the hologram might be.

- 1. Certainly the formation of the hologram must closely relate to the vision about universal Akashic records realized in terms of braided flux tubes and their non-destructive reading by interaction free measurement. Oversimplifying, for a given bit of the representation the photons scattered without interaction would kick either of the two detectors C and D associated with it to an excited state (see http://tinyurl.com/y86ysuyd). This process is very much like absorption of photons by a photosensitive plate defining an ordinary hologram.
- 2. The lipids of the cell membrane are good candidates as something in 1-1 correspondence with the basic units of this hologram (note the analogy with computer screen - also a liquid crystal!). If one irradiates the laser like system formed by the detectors not only by the radiation scattered from the quantum Akashic records but by its superposition with the reference wave of same frequency, one obtains a good candidate for a hologram. It would be defined by the excited quantum state consisting of laser systems analogous to the detectors C and D. Any piece of the system should give and approximate representation of the memory and robustness of the representation is achieved.
- 3. In semiclassical treatment the probability that a given laser like detector is excited must be proportional to the modulus squared of the net field amplitude, which is a superposition of reference wave and scattered wave Also just. as in the case of ordinary holograms, the irradiation of the laser like system by the negative energy counterpart of the reference wave (its phase conjugate emitted in a state resulting in state function reduction to the opposite

boundary of CD) effectively generates the conjugate of the scattered wave since only those parts of the system can return to the ground state with considerable probability for which the probability to go to excited state is high enough. Note that this implies that magnetic body contains geometric representations of the perceptive field as indeed assumed [K70, K71]. This is however not quite the classical hologram. Rather, the total number of absorbed negative energy phase conjugate photons for given pixel defines the "real" picture. A given point of the hologram corresponds to an ensemble of laser like detectors so that a statistically deterministic response is obtained as an ensemble average.

How to realize this concretely?

- 1. I have proposed that the lipids of cell membrane could serve as pixels of sensory representations [K59]. They could indeed serve as the pixels of conscious hologram. Each pixel should contain large number of laser like "detectors" so that statistical determinism would be achieved.
- 2. There should be pair C and D of detectors such that either of them absorbs photon in an interaction free measurement so that a value of bit is defined. Universality serves as a strong constraint as one tries to guess what C and D could be.
 - (a) The lipids at the two lipid layers of cell membrane could be in 1-1 correspondence with C and D. This option is not however universal.
 - (b) It is however quite possible that the magnetic fields involved are what I have called wormhole magnetic fields [K147], which carry monopole flux and and involve two spacetime sheets carrying opposite net fluxes. As a matter of fact, all elementary particles correspond to flux quanta of wormhole magnetic fields. In this case the two sheets would naturally correspond to detectors C and D and in the simplest situation they would have same Minkowski space projection. Universality of both detectors and holograms is achieved.
- 3. The cyclotron Bose-Einstein condensates for charged particles at magnetic flux tubes assignable to lipids are good candidates for the laser like systems if they contain cyclotron Bose-Einstein condensates. There are however several options since the magnetic flux tubes are closed and there are several ways to realize this.
 - (a) DNA as topological quantum computer vision and the view about cell membrane as a sensory receptor communicating data to the magnetic body in turn sending control signals via DNA suggest the following. Magnetic flux loops have a part connecting DNA with nuclear or cell membrane (this would be the analog for the dipole of the dipole magnetic field) and part which is long - even with size scale of Earth and corresponds to the magnetic field created by the DNA-cell membrane system. This picture applies both to the flux tubes of ordinary magnetic field and to the flux tubes of the wormhole magnetic field.
 - (b) An assumption in accordance with the general role of magnetic body is that Akashic records reside at the short portions of flux tubes connecting lipids with DNA codons: their braiding would define basic example about universal representations in living matter. The laser like detectors would reside at the long portions of the flux tubes connecting cell membrane and DNA. If wormhole magnetic fields are in question, the detectors C and D could correspond to the two parallel flux tubes carrying opposite monopole fluxes.
 - (c) Universality suggest that this picture allows many alternative realizations. In principle, the relative motion of any system (partonic 2-surfaces with light-like orbits) connected by flux tubes could give rise to Akashic records. The lipids of axonal membrane are excellent candidates for the pixels and the flux tubes connecting the lipids to microtubuli [J2] would also define Akashic records with long parts of the flux tubes serving as the laser like system. The maximization of the memory capacity would also explain why the neural pathways to brain tend to maximize their lengths by connecting right side of the body to left hemisphere and vice versa.

4. What remains still open is how to integrate the Josephson junctions defined by the lipid layers of the cell membrane to this picture.

6.4.7 Could Quantum Jump Represent The Basic Aspects Of Abstraction Process Automatically?

Could quantum jump automatically represent the basic aspects of abstraction process and its reversal as it manifests itself at the level of brain?

- 1. The sizes of CDs in the quantum superposition defining zero energy state tend to increase. This means that the time scale of sensory and cognitive representations increases. Also new sub-CDs are generated as the size scales of CDs increase and this means generation of new mental images identifiable as memories.
- 2. NMP favors the formation of negentropic entanglement between sub-CDs so that sequences of mental images with both space-like entanglement (spatial patterns) and time-like entanglement (sequences of spatial patterns) are formed. NMP guarantees their stability. Zeno effect could make possible the analog of thermodynamical equilibrium to prevail for several quantum jumps on same boundary of CD having no effect in a given length scale. If quantum jumps occur independently for several scales, they can occur simultaneously in other scales.
- 3. Map from real to p-adic sector occurs defines a cognitive representation, a prediction for the future (or past when intention is realize as action). In the ideal situation "thermal equilibrium" with respect to NMP is achieved for a given CD. Next state function reduction having observable effects occurs at the opposite boundary of CD and gives rise to motor action or intention about motor action defined by this sensory representation. The transformation to real sector realizes intention.

6.4.8 Quantum Jump As The Counterpart Of Fundamental Algorithm?

In TGD framework the materialistic identification of consciousness as a property of the physical state of brain is not made. Consciousness is assigned with quantum jump and is therefore something between two quantum worlds.

In quantum TGD context functionalism does not look like an attractive idea. However, the idea that cognitive processing as identification and naming of objects of the perceptive field could be totally universal and taking place already at the elementary particle level, does so. The additional feature would be coloring of this cognitive map. Sensory qualia would do this and could be assigned to the quantum jump and identifiable basically in terms of increments of various quantum numbers in quantum jump.

The TGD counterpart of the functionalistic dream could be dream about the reduction of basic aspects of brain function - formation of sensory and motor representations and their realization, to the basic the basic anatomy of quantum jump and properties of negentropically entangled states approximately invariant under quantum jumps. All systems, even electron would do this, but brain would be highly specialized to this fundamental process.

6.4.9 Could Quantum Computationalism Make Sense?

There are strong objections against classical computationalism but what about its quantum variant? The first question is about what one means with quantum computationalism. The usual quantum computation algorithm is modelled by classical computation and might not catch all aspects of activity that one might want to call quantum computation or more generally, conscious cognitive processing.

The vision about DNA as topological quantum computer is one of the key ideas of TGD inspired quantum biology and might actually apply to much wider class of biomolecules biological structures. The notion of magnetic body which distinguishes TGD from ordinary biology and neuroscience is central here. The braiding of magnetic flux represents topological quantum computation programs. One can actually see the braid strands connecting DNA nucleotides or triplets with lipids of nuclear or cell membrane as a representation for quantum software whereas DNA represents the hardware. The reconnections of flux tubes would generate quantum coherence between distant objects and the phase transitions changing their lengths could make possible the miracles of bio-catalysis. The so called cultural evolution could correspond to the evolution of the magnetic bodies.

Could brain - or perhaps even entire Universe - perform quantum computation in some generalized sense and whether sensory processing could be seen as quantum computation in this more general sense? In TGD framework one can consider a generalization of the notion of quantum computation so that quantum jump identified as moment of consciousness defines quantum computation in generalized sense and can be seen also as the counterpart of fundamental algorithm giving rise to sensory and cognitive representations and realizations of motor actions as their time reversals.

- 1. Generalized Feynman diagrams [K57] involve propagator lines for fermions to which one can assign topological quantum computation with basic gate identified as the basic braiding operation. These braid strands can be assigned with fermions at the ends of the light-like orbits of partonic 2-surfaces. Also the magnetic flux tubes can take the role of braid strands.
- 2. The vertices, which come in two varieties, do not have counterpart in ordinary quantum computation and seem to represent something totally new. The first vertex is the analog of string vertex and represents fusion or decay of 3-surface (or associated partonic 2-surface).
 - (a) To this vertex one can naturally assign direct sum of state spaces associated with the braid strands carrying fermions. This \oplus vertex has also time reversal and identifiable as co-vertex so that algebra and co-algebra structures are present simultaneously.
 - (b) Second vertex is not encountered in string model and generalizes the ordinary 3-vertex of ordinary Feynman diagrams. At this vertex the orbits of 3 partonic 2-surfaces meet at their common end (partonic 2-surface). Now tensor product \otimes is the natural operations and again one has algebra and co-algebra structure. These vertices are algebraically completely analogous with the ordinary sum and product.

This led to the crazy proposal that arithmetics, the notions of real and p-adics numbers, and even more general mathematical notions generalize by replacing numbers with Hilbert spaces and that calculus for Hilbert spaces could make sense [K90]. This brings in infinite abstraction hierarchy and means a huge generalization of the structure of mathematics but might be needed if one wants to understand reflective consciousness.

- 3. The replacement of points of Hilbert space with Hilbert space to get a new structure means an abstraction. Single state is replaced with a set of states defined by state basis. Could this process correspond to the formation of abstractions is at the fundamental level? If so \oplus could mean formation of quantum superposition of perceptively equivalent zero energy states representing the percept. \otimes would represent association of different percepts (say through different sensory channels) which represent same object. The superposition of tensor product states would define rule and abstraction and could be the basic cognitive process assignable to generalized Feynman diagrams.
- 4. This process would be far reaching generalization of the ordinary arithmetics with + and \times to that for \oplus and \otimes and their co-operations. The basic fact about practical arithmetics is that the same computation as a sequence of operations can be performed with very many ways but there is the shortest manner to do it. At the level of generalized Feynman diagrams this would mean huge symmetries. The physical equivalence classes of generalized Feynman diagrams would be huge and in twistor approach to generalized Feynman diagrams these symmetries have an identification as counterparts for the symmetries of twistor diagrams. Whether the representatives inside these equivalence classes are also cognitively equivalent is not clear. These observations suggest that generalized Feynman diagrams might be much nearer to what happens when human brain computes and that quantum computation in the ordinary sense corresponds only to a single line of generalized Feynman diagram, and has same relation to what really happens in brain as single particle quantum mechanics to full quantum field theory.

6.5 Philosophical And Conceptual Foundations Of Consciousness Science

Revonsuo [J13] discusses both philosophical, historical, and conceptual foundations of consciousness science. In the following I will restrict the attention to philosophical and conceptual foundations. In the following discussion the book of Revonsuo serves as excellent reference providing also references to various articles relating to the topics discussed so that I have not included them.

6.5.1 Philosophical Foundations

Revonsuo distinguishes between dualism and monism as basic approaches and discusses in detail both kind of approaches and in section "Why the mind-body problem will not go away?" considers the basic problems (explanatory gap/hard problem) shared by both approaches. In materialism the understanding of qualia, phenomenal experience, is the problem. In dualism the assumption of material and mental as separate "substances" leads to problems with the laws of physics. If one assumes that the mental causation to reduces to that of laws of classical physics, consciousness loses its causal role and becomes a mere epiphenomenon.

Quantum consciousness allows a third philosophical approach giving hopes of avoiding the problems of monism and dualism. This view is not discussed by Revonsuo. If quantum jump is identified as a moment of consciousness, the attempts to reduce the phenomenal aspects of consciousness to the properties of quantum states do not make sense. Consciousness would be in the change, in the re-creation of quantum world.

The challenge is to understand that the contents of consciousness represents also properties of the internal and external world at least approximately invariant under quantum jumps (mental images must represent useful information: rules, memory mental images, self model, model for the external world, etc...). Here quantum theory provides a solution: interaction free measurement [B2] allows to obtain conscious knowledge about subsystem (defining memory representation now) such that the probability for the change of the state can be made arbitrary small.

6.5.2 Conceptual Foundations

Revonsuo also discusses conceptual foundations of consciousness.

Phenomenal consciousness and qualia

1. Phenomenal consciousness and qualia should certainly be the central concepts of consciousness science. Ironically, in many theories of consciousness (eliminative materialism and some forms of functionalism and representationalism) qualia and phenomenal consciousness are not accepted at all so that not much remains to be explained as Dennett's "Consciousness Explained" (title of this book) expresses it.

In TGD framework quantum jumps is naturally the source of phenomenal consciousness and qualia cannot be properties of the state since they are assigned with the re-creation of the Universe in quantum jump. This means that the "-ness" in "consciousness" is not appropriate. In finnish language the word "tajunta" would be much more appropriate word.

One must of course considerably generalize the notion of quantum jump from the state function reduction of wave mechanics in order to understand basic aspects of conscious experience. In ZEO the positive energy parts of zero energy states are characterized by quantum numbers. In complete analogy, fundamental qualia can be labeled by the increments of various quantum numbers in quantum jump for positive/negative energy part of zero energy state.

2. Phenomenal consciousness seems to consists of centre and periphery. Attention seems to distinguish between centre and periphery. Whether a genuine background is present in phenomenal conscious experience is however difficult to test, say by introspection.

Change blindess and inattentional blindness are general phenomena involving no brain disorder and in strong conflict with the intuitive belief that sensory experience represents all that is present in the perceptive field. In experiments demonstrating change blindness subject person sees a complex visual scenery. A little bit later the subject person is shown second picture and told that some big change distinguishes it from the first picture. As a rule subject persons are unable to identify this change unless they have directed their attention to just the particular feature that changes. Change blindedness obviously relates to the memory representations about the earlier sensory percepts. It seems that without attention they do not become parts of the memory representation.

Inattentional blindness means that subject person concentrated on some cognitive task, does not notice unexpected stimuli in the perceptive field. A classic example is a situation in which person focuses attention to basket ball and fails to notice a person walking over the playground in gorilla mask. These findings have inspired the hypothesis that attention can be equated with consciousness and that only the target of attention is in the spotlight of consciousness. The mental image representing person in gorilla mask would not be negentropically entangled with the memory representation.

Attention

What attention could then mean in TGD framework?

1. Both change blindness and inattentional blindness that the mental images representing object of perceptive field becomes part of memory representation when it is attended. This suggests that attention corresponds to the generation of negentropic entanglement binding the new mental images to the negentropically entanglement sequence of earlier mental images. Generation of negentropic entanglement (see Fig. http://tgdtheory.fi/appfigures/cat.jpg or Fig. ?? in the appendix of this book) would characterize attention. Clearly, attention cannot be equated with consciousness.

We do not usually remember our dreams unless we wake-up immediately: could this be due to the fact that the dream mental images are not attended unless person wakes up during the dream? Could the objects of dream percept attended during lucid dreaming?

- 2. The target of attention should become a part of self + world model of the perceiver at the level of cognitive and memory representations at least. To direct attention is to store as a memory. If this does not happen, there is no potentially conscious memory about the object (memory recall would correspond to interaction free measurement) although it t could contribute to phenomenal consciousness even when it is not attended. Illusions in which subject person is deluded to identify some inanimate system as his body part are consistent with the proposed definition of attention.
- 3. I have proposed the formation of magnetic flux tubes connecting target of attention and perceiver as a space-time correlate of attention. "Perceiver" would correspond to a space-time sheet to which one can assign a negentropically entangled collection of sub-CDs representing a model for self + external world. Obviously the systems connection by a bridge of attention would form a single macroscopic quantum system. The negentropic entanglement of zero energy states associated with corresponding sub-CDs would be the quantum correlate of attention. At embedding space level the correlate could be overlap of the M^4 projections of the CDs involved.

Various meditation practices suggests that the attention can be generated also when the target is inanimate object and means the experiencer becomes one with the target of attention. The recent experiments of Persinger [J48, J49, J50] provide support for the role of magnetic flux tubes as correlates for the formation of macroscopic quantum coherence binding the two systems to single quantum system.

- 4. Selective attention would also mean a state function reduction for a particular sub-CD representing sensory mental image negentropically entangling it with the collection of sub-CD: s representing self model of perceiver but eliminating its entanglement with sub-CDs representing other objects of the perceptive field.
- 5. Attention would have metabolism as a physiological correlate. I have proposed that ATP either carries negentropic entanglement and transfers it to the target or that the energy liberated in the process ATP \rightarrow ADP generates negentropic entanglement. I have also proposed

that ATP \rightarrow ADP process means standardized manner to build reconnection in the network of magnetic flux tubes changing the connectedness of the magnetic Indra's net between biomolecules. In the case of two objects with disjoint magnetic bodies, reconnection of the flux tubes means that they become connected by a pair of magnetic flux tubes making possible negentropic entanglement. This is just what should happen when the new mental images is connected to the negentropically entangled connection of old mental images. Therefore a rather direct connection with metabolism, attention, and building of sensory representations seems to emerge.

Reflective consciousness

Reflective consciousness is second key aspect of consciousness besides phenomenal consciousness. Some consciousness theorists accept only reflective consciousness since it makes consciousness theorizing easy by allowing the reduction of brain to classical computer.

- 1. Reflective level of consciousness is typically about conscious experience itself and is often equated with the formation of representations. Becoming conscious about what one was conscious suggests however strongly that the representations are extended in this step. The binding of new mental images by negentropic entangled to a negentropically entangled collection of older mental images is what would happen in this process and the dynamics of quantum jump in ZEO would automatically induce this process.
- 2. The mathematical description of abstraction involves two elements: tensor product and direct sum. Tensor product identified as a correlate for association is the first element. The higher the abstraction level, the larger the number of factors in the tensor product. For instance, various sensory qualia are tensor producted in associative areas so that large number of different views about object a generated simultaneously.

Direct sum by superposing perceptively equivalent zero energy states represents the averaging aspect of abstraction allowing to get rid of un-necessary details and to see the wood from trees. The measure for the abstraction level for direct sum can be identified as perceptive/cognitive resolution. The notion of resolution emerges unavoidably from the notion of p-adic manifold based on cognitive maps mapping real preferred extremals of Kähler action to their p-adic counterparts and their inverses (see the appendix of the book). This map is defined only for a discrete set of rational points (also algebraic for algebraic extensions of p-adic numbers). A reasonable working hypothesis is that the preferred extremals in the quantum superpositions have same discretizations characterized by the resolution. An alternative working hypothesis is that they have same geometric correlation functions in the resolution used.

3. In particular, quantum jump typically implies the increase of the size scale of CD involved and the addition of tensor factors to the negentropically entangled structure representing self model and model for self + external world.

About the definition of consciousness

The notion of consciousness is rather fuzzy and there is large number of definitions of consciousness which emphasize some aspect of consciousness and neglect others. Revonsuo lists some definitions and discusses their failures.

- 1. Consciousness as the ability to respond to stimulation emphasizes the visible behavioral aspects of consciousness state (ability to respond to them). The problem is that pure reflex responses are not conscious-to-us and person can be fully paralyzed and still be fully conscious. Responsiveness would be better term than consciousness in this case.
- 2. Consciousness as the ability to represent information from the external world. This definition applies only to the representative part of conscious experience and one can imagine a person having phenomenal conscious but without ability to build cognitive representations. Living matter and also computers and even camera form representations about external world so that this ability obviously not complete characterization of consciousness.

- 3. Consciousness defined as wakefulness requires both awareness about self and environment and ability to respond to changes in the environment. Dream experiences represent the obvious objection now.
- 4. Consciousness as access to output systems, control of behavior or behavioral interactions with the world. Functionalists want to reduce consciousness to the existence of some inputoutput function and define consciousness as "access consciousness". Conscious information is information which can be represented verbally or realized as a motor response. This definition neglects completely the phenomenal aspects of consciousess and according to it computers are conscious.

All the definitions discussed by Revonsuo regard consciousness as a property of system. If this property is physical then consciousness becomes epiphenomenon without causal role. In TGD framework the identification of quantum jump as consciousness means that consciousness is not a property of physical world but something between two physical worlds.

6.6 Philosophical And Empirical Theories Of Consciousness

Revonsuo [J13] analyzes in detail selected philosophical and empirical theories of theories of consciousness demonstrating their problems.

6.6.1 Some Philosophical Theories Of Consciousness

Revonsuo discusses as examples of philosophical theories of consciousness.

- Multiple drafts theory of Dennet (see http://tinyurl.com/y6uoyclp) [J26],
- Sensorimotor theory of O'Regan and Noe (see http://tinyurl.com/oodtodv) [J92].
- Biological naturalism of Searle (see http://tinyurl.com/yhga9ep) [J79].
- Naturalistic dualism of Chalmers (see http://tinyurl.com/yd2dcxrk) [J25].
- Higher order theories of consciousness (HOTs) [J93] (entire industry).
- External representationalism of Tye and Dretshke (see http://tinyurl.com/ybfxkhxo) [J88, J61].
- Neurophenomenology Varela, Lutz, Thompson, and Noe (see http://tinyurl.com/618jqfy) [J4, J62].
- Reflexive monism of Velmans [J89] (see http://tinyurl.com/y84znmdv).
- Virtual reality theory of Metsinger and Lehar [J100, J104]. The book of Revonsuo gives a lot of references to these theories.

In the following some comments about these theories from TGD vantage point.

1. Dennett can be seen as eliminative materialist and functionalist. Dennett's theory denies qualia, phenomenal consciousness, and subjectivity - all that is usually counted as core elements of consciousness - and accepts only representational, narrative consciousness. Consciousness accompanies complex, parallel information processing system in this framework and complex enough computer is conscious in Dennett's Universe. "Multiple drafts" means that different streams of information are competing with each other to get access to output systems - or to gain fame in brain - as Dennett puts it. The competition for metabolic resources between sub-selves could correspond to this competition in TGD framework.

- 2. Sensorimotor theory of O'Regan and Noe defines consciousness as ways of acting or as something we do, rather as phenomenal experiences or internal representations. The relation to the external world becomes decisive. The conclusion is that consciousness does not involve brain activity at all so that the search for neural correlates of consciousness would be waste of time. Also the notion of phenomenal consciousness is rejected. There are obvious killer objections against sensorymotor theory. People who are totally paralyzed can still be conscious. Dreams whose reality even very few philosophers are ready to deny serve as a second killer objection against the theory.
- 3. Biological naturalism of Searle identifies consciousness as a biological phenomenon, a higher level emergent feature of brain activity. In accordance with the materialistic dogma conscious phenomena would be caused by the neurobiological properties of neuronal systems and consciousness has no causal powers. Subjectivity - first person ontology as philosopher would put it - is however accepted and not assumed to reduce to any objective neurophysiological phenomenon so that consciousness becomes more or less a miracle. The theory therefore assumes strong emergence as opposed to weak emergence meaning that consciousness can be explained using physics. The problem is that there is no ideas about the systems for which phenomenal consciousness should emerge.

In TGD framework quantum jump would bring in subjectivity. Miracle like emergence is not needed and subjectivity is assigned with a basic process of quantum physics.

4. Chalmers is known for introducing the hard problem (see http://tinyurl.com/2ws2zq): How any physical system can product any experiential, qualitative states at all? Chalmers's naturalistic dualism is a dualistic theory which does not regard phenomenal experience as a part of the physical world but accepts it as an internal representation of information. Chalmers does not however postulate "eternal soul" as Descartes did. The consistency with the laws of physics forces to conclude that consciousness has no causal powers. Chalmers approach implies panpsychism: all physical systems have some kind of phenomenal consciousness.

The solution of hard problem in TGD approch relies of the identification of quantum jump as moment of consciousness. Consciousness is not assigned with the state but with its change. Panpsychism is unavoidable and self hierarchy expresses this concretely. In TGD consistency with the laws of quantum physics is achieved and the more refined view about quantum jump allows to understand the basic sensory input-motor action sequence at various levels of self hierarchy.

5. In higher order theories (HOTs) consciousness is always reflective consciousness. Phenomenal consciousness is denied and all conscious experiences are representational (intentionality, aboutness, directedness). HOTs deny consciousness from all creatures no able to formulate higher order thoughts. Therefore infants and animals are doomed to be unconscious zombies in HOT universe.

In TGD framework the negentropically entangled states defining abstractions and rules at various levels of hierarchy would define almost invariants. In the recent formulation one must assume that negentropic entanglement gives rise to conscious information. This conscious information would be the only kind of conscious information accepted in HOTs as conscious information.

6. Externalistic representationalism (Tye, Dretske) assumes that brain constructs only representations of inputs coming from the external world. Therefore also phenomenal aspects, qualia, are something in the external world and only represented in brain. Redness of rose is thus a property of rose, not something generated by the absorption of photons of certain wavelength in retina. The idea that the visual perception of distant galaxy would mean direct experiencing of its visual qualia seems rather strange - at least in the universe of standard physics. The question how the qualia of external world are represented in brain represents a difficult problem for externalistic representationalism.

The idea that sensory qualia are in the external world looks rather weird in standard physics framework. In TGD framework qualia are assigned with sensory organs defining the boundary between internal and external world for a given CD. In TGD Universe consciousness is however not restricted to brain. The hierarchy of dark matter realized as phases with effective value of Planck constant coming as integer multiple of the ordinary Planck constant and residing at magnetic flux quanta makes macroscopic quantum coherence possible in arbitrarily long length and time scales so that it is quite possible to imagine that the contents of our conscious experience can contain contributions from quite long length and time scales.

p-Adic space-time sheets have literally infinite size in real sense (this statement makes sense for common rationals and some common algebraic points) so that cognition is in TGD framework a cosmic phenomenon and only cognitive representations defined by the discrete intersections of real and p-adic space-time sheets are located inside CDs.

6.6.2 Some Empirical Theories Of Consciousness

Revonsuo discusses also current empirical theories of consciousness taking as examples the following theories.

- Global workspace theory [J18] (Baars, see http://tinyurl.com/ycvmgn96).
- Neurobiological theory [J24] (Crick and Koch, see http://tinyurl.com/y8wkg32).
- The dynamic core theory [J28] (Tononi and Edelman, see http://tinyurl.com/ycngrbvv).
- The integrated information theory [J63] (Tononi, see http://tinyurl.com/y995nmqp).
- Thalamocortical binding theory [J96] (Llinas, see http://tinyurl.com/yadnttno).
- Recurrent processing theory [J108] (Lamme, see http://tinyurl.com/ycmmeh8o).
- Microconsciousness theory [J101] (Zeki, see http://tinyurl.com/yc4yfdse).
- Consciousness as the feeling of what happens [J11] (Damasio, see http://tinyurl.com/ f75kp).

In the following some TGD inspired comments about these theories.

- 1. The neurobiological theory introduced the hypothesis that 40 Hz frequency assignable to thalamocortical resonance (see http://tinyurl.com/8vt8pzu) is fundamental for binding the conscious experiences. The motivation is that thalamus has dense net of bi-directional loops to cortex. It turned out later that this resonance is strong only when the objects of perceptive field are recognized.
 - (a) A possible TGD inspired interpretation is based on the observation that negentropic entanglement is generated during the sensory perception as the sensory mental image or its representation at cortex negentropically entangles with the earlier sensory mental image or its cortical representation to form an updated memory representation. This stage could involve 40 Hz resonant interaction with the earlier stored sequence of sensory memories giving rise to the negentropic entanglement (the process is driven by NMP).
 - (b) The experience of understanding that I earlier erratically assigned with negentropic entanglement (in conflict with NMP!) would be assigned with the *generation* of negentropic entanglement (in accordance with NMP!) and with the defining postulate of TGD inspired theory of consciousness. Revonsuo has performed an experiment which demonstrates that 40 Hz resonance appears when a random looking visual pattern consting of dots and short line segments is recognized to represent 3-D object but fades out after the recognition [J12]. The finding conforms with TGD based interpretation.
 - (c) In TGD framework thalamus would suggest itself as a central self representing "me" having as sub-selves the negentropically entangled mental images assignable to cortex (reflective consciousness) and the sensory mental images assignable to various sensory organs (phenomenal consciousness).

2. Damasio's theory emphasizes the importance of emotions as a basic building brick of conscious experience. In TGD framework emotions are associated with negentropy: positive emotions correspond to negentropy gain and negative emotions to negentropy loss. NMP states that the information gain in state function reduction is maximal and is therefore analogous to second law and indeed implies for ordinary entanglement second law at the ensemble level [K80]. NMP suggests the analog of thermodynamics and even non-equilibrium thermodynamics for negentropic entanglement. In the presence of constraints on zero energy states (fixed average energy, particle number, etc..) this would imply existence of parameters analogous to temperature, pressure, etc..) so that the use of thermodynamical quantities as metaphors for the macro aspects of consciousness would have justification. In this picture emotions define a central element of experience.

6.6.3 Major Issues Of Disagreement Between Theories

Revonsuo summarizes the two chapters by discussing the major issues of disagreement between theories of consciousness. These issues concern the location of consciousness (externalism vs. internalism), the fundamental nature of consciousness (phenomenology vs. cognition), and fundamental form of phenomenal consciousness (atomism vs. holism).

Internalism vs. externalism

Internalism and externalism are basic views about the location of phenomenal conscious experience.

- 1. Internalism assumes that the neurophysiological and functional state of the brain determines the contents of consciousness. It seems possible to understand the representational aspects of consciousness: brain decomposes sensory field to objects and gives them names represented as patterns of neuronal activity. The understanding of how phenomenal consciousness, qualia, is not so easy. The neurons look the same everywhere and it has not been possible to point out or even imagine how the organizational structure of the neurons could give distinguish between say hearing, vision, and touch although they all carry geometric and dynamical information.
- 2. Externalism locates qualia in the external world and that brain only represents them. This option has been already discussed.

What happens in TGD Universe?

- 1. The first thing to observe is that in TGD framework it is not possible to locate consciousness anywhere: consciousness is in the quantum jump, between two zero energy states of the Universe. The contents of consciousness can be however localized and one could ask whether the seat for the contents of conscious experience is located inside or outside brain. Actually this is too limited formulation if one takes seriously the self hierarchy and the notion of magnetic body implying that brain alone is not the seat for the contents of consciousness in TGD Universe.
- 2. In TGD framework both internalism and externalism are both right and wrong: qualia are in the intersection of external and internal worlds defined appropriately. Sensory organs define examples about this kind of intersection but there is fractality involved. Also cell membranes can be seen as sensory organs. This picture follows from the basic assumptions of quantum TGD.
 - (a) Strong form of general coordinate invariance implies strong form of holography. Already holography implies that space-time surfaces as carriers of geometric information provide classical space-time correlates associated with the light-like 3-surfaces representing the orbits of partonic 2-surfaces representing boundaries between space-time regions with Euclidian and Minkowskians signatures of the induced metric. By strong form of holography these partonic 2-surfaces and the 4-D tangent space data of space-time surface at them are enough to fix zero energy states: I call this effective 2-dimensionality.

The partonic 2-surfaces have interpretation as boundaries of physical objects in all scales and they carry the quantum numbers and therefore also the quantum number increments are associated with them and therefore also phenomenal consciousness and qualia. The space-time regions of Minkowskian and Euclidian signature of induced metric define the space-time correlates of "internal" and "external". The partonic 2-surfaces are therefore identifiable as seats of conscious experience. It is important to notice that there is entire fractal hierarchy of partonic 2-surfaces. Partonic 2-surfaces can be also connected by strings carrying fermion number and these string world sheets connect different partonic 2-surfaces: string oscillations define sound as a fundamental phenomenon and are behind hearing and internal speech as already proposed.

(b) Strong form of holography implies that partonic 2-surfaces and their 3-D orbits are very much like sensory organs which indeed define boundary between internal and external worlds. This motivates the assignment of qualia to sensory organs. The fractal generalization suggests that even elementary particles enjoy primitive phenomenal consciousness. p-Adic physics as physics of cognition suggests that even primitive cognition is associated with elementary particles.

This would elegantly solve the basic objection against internalism since qualia would indeed strongly correlate with their physical cause (oscillations of string like objects in 4-D space-time possibly underlying sound waves, photons and possibly also other masless bosonic quanta at various wave lengths underlying vision, physical touch having topological correlate in TGD Universe).

Phantom limb and dreams define the basic objections against this picture but it is possible to circumvent these objections if one accepts feedback from brain to sensory organs as virtual sensory input realized as dark photons travelling along magnetic flux tubes, and TGD based view about time allowing to interpret pain in non-existing limb as a sensory memory. Also erratic assignment of position to the actual pain somewhere else than non-existing limb can explain phantom pain. This kind of mis-assignments can be produced as illusions at the level of sensory representations.

(c) There is however a question to be answered. Space-time regions can have Euclidian or Minkowskian signature of the induced metric. Does holography hold for both and do the light-like 3-surfaces between them represent holographically both. For instance, can one assign the two representations two the two sides of this 3-surface and for strong form of holography to partonic 2-surfaces and the tangent space data at the two sides of space-like 3-surface at the boundary of CD?

Do these two representations define representations of internal qualia (virtual input from sensory representations) and external qualia (real input from external world)? Is the comparison of the virtual input generated by sensory representation with external input crucial in the construction of sensory representations: sensory representation is faithful only when these qualia are opposites of each other (when defined in terms of quantum number increments). One can get convinced about the reality of virtual qualia by swimming for some time in windy sea. At the beach the wave motion continues in the body and can make walking difficult.

Representational aspects of consciousness are usually identified as internal aspect localizable inside brain. In TGD framework the notion of magnetic body forces to challenge this assumption.

1. Negentropically entangled subsystems tend to remain unchanged under the dynamics dictated by NMP even at the active boundary of CD and therefore represent information as quantum rules as superpositions of their instances. At passive boundary negentropic entanglement is absolutely stable during the lifetime of self. Thus the negentropic entanglement at the passive boundary of CD corresponds to what one might call unchanging self.

The representations for declarative memories, a model for external world, self model, predictions of future, plans for motor action and future, ...: all this night allow representations would be associated with the active boundary of CD and could be represented in terms of bits. 2. One can thus imagine memory representations based on bits and reading of them using interaction free measurement, which in ideal situation leaves the bit representations unaffected. Elizur-Weizman bomb tester is an excellent representation (see http://tinyurl.com/y9zenssv) for this. It involves ordinary state function reduction.

The outcome of state function reduction tells whether the bomb can act as quantum measurement apparatus or not (is it active or not) and at idealized limit the state of bomb is not changed (it does not explode). The reading of bits from memory is possible if bit 1 (say) can take the role of active state of bomb and bit 0 that of dud. In the bomb tester model the measured state corresponds to a superposition of two photon paths such that the other one traverses the bomb and induces explosion if state function reduction to this path takes place. The reduction to the other path does not induce explosion. The value of bit would correspond to the two states of the bomb and memory bit 1 would make the system able to perform quantum measurement. One can ask whether the ability to make quantum measurement is something fundamental and determined by whether the entanglement between system and measured system is negentropic or ordinary.

- 3. There is no reason to localize the representational states to sub-CDs inside brain although cognitive representations and naming of objects of perceptive field might be carried out by brain. The memories and plans of future (related by time reflection) could correspond to something in their real time scale and at the level of magnetic bodies this would mean size scale of Earth (EEG as communication tool to magnetic body) and even light years! Also scaled variants of these representation are expected by fractality and these zoom-ups and zoom-downs defining "stories" might be one of the key features of intelligence.
- 4. In the case of cognition having p-adic space-time sheets as space-time correlates, it is impossible to locate even contents of consciousness to a finite space-time region in real sense. Cognitive representations consisting of common rational and possibly also some algebraic points of real and p-adic preferred extremals of Kähler action, can be however said to be located to a finite volume of space-time defined by causal diamond.

Phenomenology vs. cognition

As already noticed, in TGD Universe even representational consciousness reduces always to phenomenal consciousness. Imagination and internal speech represent our experiences about phenomenal consciousness at neuronal level and the representation - as we experience it - does not carry sensory qualia. Contrary to the original wrong intuition, interaction free measurements do not allow to deduce what negentropic entanglement is - this must be directly experienced. They could however allow measurements of say memory bits leaving them unaffected in arbitrary good approximation.

The interaction free measurement could be realized in terms of photons and also as sound waves with absorption of phonon replacing the absorption of photon. This could give rise to internal speech and eventually to written language. This suggests that neuronal vision *resp.* hearing is fundamental for imagination *resp.* internal speech. One can also wonder whether there exists a translation of the worlds of language to visual images.

Atomism vs. holism

Atomism postulates that conscious experience can be decomposed to fundamental building bricks defining "micro-consciousness" in the same sense as matter consists of elementary particles. Holism in turn assumes that the experience is holistic and does not have this kind of decomposition.

In TGD framework the presence of self hierarchy changes the situation. One has fractal hierarchy of levels of consciousness having length scale hierarchy of CDs as embedding space correlate and p-adic length scale hierarchy as space-time sheets as space-time correlate. One can identify fundamental qualia as increments of quantum numbers dictated by the symmetries of TGD Universe. On the other hand, the geometric aspects of experience related to the patterns defined by subsystems of negentropically entanglement subsystems defining representative aspects of consciousness do not reduce to fundamental qualia.

6.6.4 Common Beliefs Consciousness Theories From TGD Point Of View

It seems that most theories of consciousness agree in some key aspects.

1. Brain serves as a seat of consciousness including phenomenal experience in the case that qualia and phenomenal experience are accepted at all as something real. The causal powers of consciousness are denied since in the ontology inspired by classical physics this would lead to difficulties.

In TGD framework the situation is different. Brain is the seat of sensory and cognitive representations whereas phenomenal consciousness can be assigned with sensory organs. Qualia can be assigned to quantum number increments associated with quantum jump and sensory representations become conscious via secondary qualia realized as internal speech and imagination.

2. The privacy of consciousness seems to be accepted as something totally obvious. This has been formulated as question "What it feels to be a bat" claimed to have no answer.

In TGD framework self hierarchy and the notion of magnetic body (field body) encourages to give up the belief on privacy of consciousness. Magnetic flux tubes are identified as spacetime correlates for attention binding some parts of the systems connected in this manner to single quantum system so that sharing of mental images becomes possible: therefore the claim that it is not possible to feel what it is to be a bat might be wrong in TGD Universe. For a scientists it is of course very difficult to take seriously the claim that shaman could directly experience what it is to be a bear: maybe scientist should be ready to reconsider their belief system in this respect.

6.7 Disorders Of Consciousness

Revonsuo [J13] discusses also various disorders of consciousness typically associated with representative and reflective aspects of consciousness. These disorders pose strong constraints on the theories of consciousness.

In TGD framework the generation of negentropic engtanglement (directed attention) is the basic mechanism making possible the updating of memory representations. If this mechanism fails, the outcome is a disorder explaining various neuropsychological deficits of consciousness and neurophysiological dissociation of consciousness from behavior. Failure to generate negentropic entanglement at all or generation of the negentropic entanglement with wrong memory representation would be the basic reasons for disorders. At physiological level ATP \rightarrow ADP transition generates flux tube connections giving rise to negentropic entanglement so that the problem could reduce to dysfunction at this level.

6.7.1 Neuropsychological Deficits Of Visual Consciousness

The first kind of anomalies discussed by Revonsuo are neuropsychological deficits of visual consciousness. Examples of this kind of deficits are visual agnosia: loss of coherent visual objets, semantic dementia: loss of the meaning of objects, asimultangnosia: loss of the phenomenal background, neglect: loss of phenomenal space, and akinetopsia: loss of visual animation.

These anomalies clearly demonstrate the modular character of the information processing in brain. In TGD framework this corresponds to negentropic entanglement for systems representing various components of experience and represenging abstract rules. Neurophysiological deficit could imply that some component is missing (say emotional component giving meaning to the objects in semantic dementia or component representing phenomenal background). Second possibility is that the components are not at all organized to form a negentropically entangled tensor product (visual agnosia).

Loss of visual animation could mean that the sequence of negentropically entangled sub-CDs (time-like entanglement) representing the positition of object in space has too low temporal resolution. In other words visual mental images are updated with too low frequency. The resolution needed to experience discrete sequence of imagines as a continuous motion corresponds to at least 50 Hz frequency for visual mental images.

6.7.2 Neuropsychological Dissociations Of Visual Consciousness From Behavior

Second kind of anomalies correspond to neuropsychological dissociations of visual consciousness from behavior. Examples are blind sight, implicitly visually guided action, implicit face recognition in prosopagnosia, implicit recognition of words and objects in neglect. In most theories of consciousness self hierarchy has only one-level so that the only interpretation is that there is an appropriate zombie represent making possible these dissociations but carrying the information needed for the action in question. In TGD framework also this information would be conscious albeit not conscious-to-us.

- 1. Consider first the dissociation from of sensory consciousness from motor action. As described above, ZEO more or less forces to conclude that for given CD there are two "mes" corresponding to lower and upper boundary of CD and they correspond to sensory me and motor me for which motor action is time reversed sensory perception. Thus the motor me, I_m , could enjoy time reversed sensory consciousness.
- 2. The minimal option is that the dissociated sub-self is present but does not entangle negentropically to the sub-self system of "me" representing memory mental images. Sensory "me" I_s would have sensory qualia but since it does not attend to the target of perceptive field would not remember anything about it. I_m would have not only the time reversed sensory qualia and they would also negentropically entangle with time reversed memory representations defining plans and volitions. This would mean that motor actions using sensory information would be possible.

A person suffering from blind vision (cortical blindness is not in question) reports that she is unable to see consciously but her visual areas are intact and she demonstrates the access to visual information via successful motor activities. It could be that person has still retinal vision but this phenomenal visual images do not negentropically entangle with cortical representations so that there are no conscious visual qualia or remembered visual qualia.

The proposed picture suggests that both the sensory I_s and motor "me" I_m assignable to sub-CDs in a time scale of say.1 seconds could have phenomenal vision. Only I_m could however build sensory representations consistent with incoming information (containing also the retina level representation in the tensor product). As mental images of CD these representations would correspond to volitions, decisions, and plans: this information would be enough for coherent motor activities.

The unability to recognize faces could be due to the fact that the name of person represented as sub-CD is not negentropically entangled with the collection of visual mental images representing the face. Same applies to inability to recognize words and objects. Implicit recognition however occurs and manifests itself in measured changes of skin conductance. This would suggest that emotional response is still present and realized as negentropic entanglement of the visual sub-CD with emotional sub-CD and expressing itself motorially as change a in skin conductance. The change of skin conductance would therefore be neurophysical correlate for time reversed sensory input.

6.7.3 Neuropsychological Disorders Of Self-Awareness

Neuropsychological disorders of self-awareness represent third kind of anomalies of consciousness discussed by Revonsuo and include amnesia, split-brain state, anosognosia, asomatognosia, and deficits of belief systems (delusions). An interesting observation is that left-hemisphere acts as a rationalizing interpreter capable of amazing self deceptions and right hemisphere takes the role devil's advocate.

1. In the case of amnesia the patient lives in eternal now but can remember the events before he became amnesic. Hippocampus seems to be at least partially responsible for constructing memories so that either memory construction or memory recall fails for these memories. One possibility is that for some reason the sensory mental images representing personal history are not anymore negentropically entangled in time direction so that self model is not up-dated. 2. Split-brain state is artificially induced by splitting the corpus callosum. In this state patient behaves as had possessed two separate selves, which can have conflicting future plans, desires, and actions. This seems to be in strong conflict with standard views about consciousness but if one accepts self-hierarchy this is just what is expected. Corpus callosum would entangle the different brain hemispheres to single unit.

The non-trivial topology of TGD space-time makes also sharing of mental images possible since two unentangled selves can have entangled sub-selves. This corresponds to a situation in which one has two space-time sheets which are disjoint but there are smaller space-time sheets (sub-selves) topologically condensed on them and connected by flux tubes. In the appropriate resolution the larger space-time sheets are un-entangled whereas smaller spacetime sheets in their own and better resolution are entangled.

3. In the case of asognonosia thr patient has some deficit but is not conscious about it, and fabulates all kinds of explanations for why the deficit manifests itself in this behavior. The deficit could be paralysis, cortical blindness, neglect of second half of perceptive field, or something else. The simplest explanation is that the self-model is not updated so that basically a failure of negentropic tensor producting would be in question.

A cortically blind person suffering Anton's syndrome claims that he sees. If qualia are seated at sensory organs, person could have genuine visual qualia if the retina is intact. Flawless sensory representations are necessary for a successful motor action since the zero energy state resulting in motor action is obtained by state function reduction from the zero energy state defining sensory and memory representations. Therefore the loss of appropriate cortical visual representations would make person effectively blind even if phenomenal vision is intact.

Patient can also suffer from paralysis and refuse to admit that something is wrong. Besides the general explanation one could also consider the possibility that motor representations still contain the lowest level as time reversed sensory representation. This explanation would be analogous to that for Anton's syndrome.

4. In asomatognosis person denies the possession of part of his own body. Also this disorder could be understood if the representation of that part of body is not negentropically entangled with representations of other parts of the body.

6.8 Altered States Of Consciousness

Revonsuo [J13] devotes three chapters to altered states of consciousness (ASC) discussing dreaming and sleep as ASCs, hypnosis as a candidate for ASC and higher states of consciousness as ASCs.

6.8.1 Dreaming And Sleep As ASC

The first chapter about ASCs is devoted to dreaming and sleep as altered states of consciousness. Hypnagogic and hypnopompic hallucinations, sleep paralysis, sleep mentation vs. dreaming, the contents of dreaming, lucid dreaming, bad dreams and nightmares, night terrors, sleepwalking and nocturnal wander, and sleep behavior disorder and dreamwalking are the titles of the sections and give a good overall view about topics discussed.

In preceding sections I have already discussed TGD view about dreams as virtual sensory experiences generated by the input from brain or even magnetic body to the sensory organs, which in TGD Universe serve naturally as seats for the contents of phenomenal experiences. This interpretation distinguishes TGD from the competing theories of consciousness.

6.8.2 Hypnosis

Second chapter about ASCs is devoted to hypnosis (see http://tinyurl.com/mgy2e) as a possible candidate for ASC and discussed hypnotic induction and hypnotic suggestivity.

Hypnosis can be seen as a challenge to the cherished belief about the privacy of consciousness. Hypnotist and subject person indeed seem to form a larger coherent unit in which the motor system of the subject person becomes effectively part of the motor system of hypnotist. Hypnotist can also induce suggestions giving rise to sensory experiences what could be regarded as hallucinations, perhaps by inducing virtual sensory inputs, which also can be seen as motor actions in very general sense. The formation of negentropic entanglement by the generation of magnetic flux tubes connecting the subject person and hypnotist would be part of the TGD based model. This would allow the hypnotist to negentropically entangle with the self model of the subject at highest level and realize his volitions using the motor system of the subject person [K64].

6.8.3 Higher States Of Consciousness

The third chapter devoted to ASCs is about higher states of consciousness: meditation, optimal experience and flow, runner's high, OBEs, NDEs, and mystical experiences. In several experiences of this kind sensory input and motor activity contribute minimally to the conscious experience. Typical for OBEs is that person sees his own body from third person perspective.

Remark: Besides genuine OBE like experiences I have personally had also OBE like experiences in which I see my body in somewhat surreal perspective and find myself floating in the roof and thinking hardly for possible tests whether I am really levitating.

OBEs and in particular NDEs obviously challenge the belief that brain alone is the seat of consciousness. Therefore it is not surprising that both OBEs and NDEs are labelled as pathological in materialistic approach to consciousness (or what is left from it after application of the basic dogmas). It is of course possible that this kind of conscious experiences become possible under some brain disorders such as epilepsy.

The explanation of NDE as a kind of final activity of a dying brain looks rather artificial: especially so because these experiences are highly structured and coherent and rather universal rather than being chaotic as one might expect if the state of consciousness corresponds directly to the state of brain as materialistic dogma states.

OBEs and **NDEs**

TGD suggests the following approach to OBEs [K127] and NDEs.

- 1. The notion of magnetic body (bringing in mind the "aether body" of the esoteric teachings) could have central role in TGD inspired quantum biology and neuroscience, and especially so in the explanation of OBEs and NDEs. EEG and its scaled variants would provide control and communication tool for the magnetic body and also lower frequencies than those appearing in EEG could be involved so that the flat EEG during NDEs would reflect only the absence of sensorimotor activities.
- 2. The highest level sensory representations would be naturally realized at magnetic body and give rise to sensory representations about biological body and even its environment and in this manner give rise to the third person aspect of consciousness. If this is the case, one could understand how it is possible to see own biological body as an outsider during OBEs and NDEs.

The representations at the magnetic body could in turn generate virtual sensory input as a feedback down to the level of sensory organs also in the ordinary wake-up consciousness as a check that these representations are consistent with the sensory input. The mechanism for generating the sensory input as dark photons and perhaps also dark phonons has been already suggested.

- 3. This model is consistent with the correlation of these experiences with the epileptic seizures. Epileptic seizure could lead to a failure to communicate sensory data to the magnetic body by EEG and also to a failure to receive signals from the magnetic body reflecting itself as chaotic motor activities. Therefore the contribution of magnetic body and third person perspective would dominates the experience.
- 4. One can argue that in absence of sensory input and motor activity, and perhaps even neural activity (EEG in many NDEs is flat) the contribution of the magnetic body to the conscious experience dominates. Magnetic body could provide the virtual sensory input even during ordinary dreams and dreams might be seen as a kind of simulation of the external world

by virtual input from the magnetic body and as brain level interpretation for what possibly happens at the level of the magnetic body. Also motor actions could be simulated as motor actions of the magnetic body. Maybe purely mental image exercises known to have genuine effect on motor skills could be interpreted as motor exercises performed by magnetic body!

- 5. Also some illusions such as moving train illusion (the sensation that the stationary train in which person is sitting moves induced by a train passign by) could be understood as resulting from the motion of personal magnetic body relative to the biological body. The moving train catching the attention of the subject person (recall the proposal that attention has magnetic flux tubes as a correlate) would anchor the magnetic body of the subject person to its rest system.
- 6. The unpleasant sensation of falling down near a precipice could be due to the imagined falling down. It would be magnetic body which represents the falling down and its acceleration with respect to the biological body generates the sensation. Magnetic body quite generally simulate the motion of biological body and the discrepancy between the simulation and real motion of biological body would generate a conscious experience. If the simulation is ideal, no conscious experience would be generated. This would allow to understand why the learned skill becomes unconscious routine. Similar simulations would take place already in the case of sensory input as already proposed. If time reversal relates motor activity and sensory perception, this kind of symmetry is very natural.

Mystical states

The third chapter about ASCs is about mystical states. Mystical experiences have often longlasting effects on the life of the experiencer as increased spontaneity and courage to choose one's own way to live. Typically it is difficult to express verbally the contents of experience: for instance, the writings of Krishnamurti emphasize this. I have had some spontaneous mystical experiences of my own, and in the following I will take the liberty to insert remarks about them to the nice summary of Revonsuo about emotional, cognitive and perceptive aspects of mystical stats.

- Emotionally mystical states are highly positive: peace, calmness, harmony, love, joy, awe, bliss are the words used to characterize the emotional state. The realization that everything in the Universe has a deep hidden meaning makes these experiences so special. Universe is experienced a a holy place, not at all that dirty world of everyday experience.
- Mystical states involve the experience of deep understanding of underlying principles of existence and direct answers to deep questions about life and existence. Dramatic expansion of consciousness to even cosmic consciousness is also reported. There is also a direct experience about hierarchical structure of conscious existence and about communication with higher levels of the hierarchy. In religious experiences God represents one (in monoteistic religions often the only accepted) higher level in the hierarchy.

Remark: In my own mystical experiences I had deep experience of understanding but without knowing what it was that I understood. In the light of afterwisdom the ideas that I became conscious of during these experiences for almost three decades ago could be interpreted as precognitions about some basic ideas of TGD and TGD inspired theory of consciousness.

• Mystical states are also accompanied by a heightened sensory consciousness. The world looks extremely bright, clear, brilliant, colorful, and pure.

Remark: My own experiences began with the increase of the experienced intensity of the sounds from environment.

- *Remark*: The experience about own body can change dramatically. The usual unpleasant sensory noise suddenly disappears and the entire body ends up to what might be called fluid like state: experience is akin to the sensation localizable to spine that music sometimes creates. In my own case this was actually the beginning of the experience.
- enlightenment experiences are regarded as the highest form of mystic experience and involves the experience timelessness, emptiness, liberation from all attachments, and the realization that even self is an illusion.

Could one say something interesting about these experiences in TGD framework?

- 1. The experience about hierarchical structure of consciousness is certainly consistent with TGD view which however derives from the mathematical structure of the theory (fractal hierarchy of quantum jumps) rather than being assumed on basis of my personal mystical experiences.
- 2. The generation of negentropic entanglement should be accompanied by the experience of understanding and the large increase in the size of personal CD could generate large amount of negentropic entanglement. This could also explain the strongly positive emotional coloring of the experiences in general. The experience of understanding would mean genuine understanding but perhaps at levels remaining unconscious or indescribable using the existing tools of language.
- 3. The generation of negentropic entanglement (see Fig. http://tgdtheory.fi/appfigures/cat.jpg or Fig. ?? in the appendix of this book) at the scales of biological body leading to enhanced quantum coherence could create the dramatic change in the experience about own body.
- 4. The personal magnetic body could be significant in mystic experiences. A phase transition increasing \hbar_{eff} could scale up the size of some parts of the magnetic body. Reconnection mechanism could make possible fusion of the magnetic body with other magnetic bodies: this could relate to the sensation of becoming one with the external world and disappearance of separations. Krishnamurti has beautifully described the experience of becoming the people around him. Also t this experience challenges the belief on absolute privacy of consciousness.
- 5. The hierarchy of quantum jumps assignable to the hierarchy of CDs with various scales is basic prediction of TGD inspired theory of consciousness. The characteristic time scale of long term memories and planned action and size scale of the perceptive field are natural characteristics for the level of self in self hierarchy. Mystic experiences could correspond to a state function reduction leading to an especially large average size scale of CDs involved in quantum superposition of zero energy state representing "me". This would mean higher abstraction level and large. A phase transition leading to an exceptionally large increase of the effective Planck constant \hbar_{eff} scaling up the size of CD is a good guess for what might happen.
- 6. Could one find quantum correlate for the experience of understanding without any mental images and without knowing what it is that one understands? This seems to be the case on both reported and my personal experiences. Hence I am forced to ask whether the invariants defined by various representations could be experienced directly in absence of the memories generated by interaction free measurements and giving rise to cognition. The "Akashic records" defined by the negentropically entangled representations would be the counterpart for this wisdom, which can be only felt but not expressed using language or pictures. Accepting this would force to give up the hypothesis that the change in quantum jump alone contributes to conscious experience: also what remains invariant in quantum jump would do so.

Acknowledgements: I want to express my gratitude for Lian Sidorov for generously providing abstracts and other material as well as for inspiring discussions.

Chapter 7

TGD Inspired Comments about Integrated Information Theory of Consciousness

7.1 Introduction

I received a link to a very interesting article by John Horgan in Scientific American with title "Can Integrated Information Theory Explain Consciousness?" [J76] (see http://tinyurl.com/ h7btppb). Originally IIT is a theoretical construct of neuroscientst Giulio Tononi (just Tononi in the sequel). Christof Koch is one of the coworkers of Tononi. IIT can be regarded as heavily neuroscience based non-quantum approach to consciousness and the goal is to identify the axioms about consciousness, which should hold true also in physics based theories. The article of Horgan was excellent and touched the essentials and it was relatively easy to grasp what is common with my own approach to consciousness and comment also what I see as weaknesses of IIT approach.

To my opinion, the basic weakness is the lack of formulation in terms of fundamental physics. As such quantum physics based formulation is certainly not enough since the recent quantum physics is plagued by paradoxes, which are due the lack of theory of consciousness needed to understand what the notion of observer means. The question is not only about what fundamental physics can give to consciousness but also about what consciousness can give to fundamental physics.

The article "Consciousness: here, there and everywhere" of Tononi and Koch [J107] (see http://tinyurl.com/zgm985f) gives a more detailed summary about IIT. The article "From the Phenomenology to the Mechanisms of Consciousness: Integrated Information Theory" [J90](see http://tinyurl.com/z9s4k7n) gives a more techanical description of IIT. Also the article of Scott Aaronson [J99](see http://tinyurl.com/zarjfzz) was very helpful in providing computer scientific view about IIT and representing also mathematical objections.

In the article [J90] it is emphasized that IIT is a work in progress. This applies also to TGD and TGD inspired theory of consciousness. Personally I take writing of TGD inspired commentary about IIT as a highly interesting interaction, which might help to learn new ideas and spot the weaknesses and imperfections in the basic definitions of TGD inspired theory of consciousness. If TGD survives from this interaction as such, the writing of these commentaries have been waste of time.

The key questions relate to the notion of information more or less identified as consciousness.

- 1. In IIT the information is identified essentially as a reduction of entropy as hypothetical conscious entity learns what the state of the system is. This definition of information used in the definition of conscious entity is circular. It involves also probabilistic element bringing thus either the notion of ensemble or frequency interpretation.
- 2. In TGD the notion of information relies on number theoretical entanglement entropy (EE) measuring the amount of information associated with entanglement [K80]. It makes sense for

algebraic entanglement probabilities. In fact all probabilities must be assumed to belong to algebraic extension of rationals if one adopts p-adic view about cognition and extends physics to adelic physics involving real and various p-adic number fields. Circularity is avoided but the basic problem has been whether one can apply the number theoretic definition of entanglement entropy only in p-adic sectors of the adelic Universe or whether it applies under some conditions also in the real sector. Writing this commentary led to a solution of this problem: the state function reduction in the intersection of realities and p-adicities which corresponds to algebraic extension of rationals induces the reductions at real and padic sectors. Negentropy Maximization Principle (NMP) maximizes the sum of real and various p-adic negentropy gains. The outcome is highly non-trivial prediction that cognition can stabilize also the real entanglement and has therefore causal power. One can say that cognition tames the randomness of the ordinary state function reduction so that Einstein was to some degree right when he said that God does not play dice.

3. IIT identifies qualia with way, which I find difficult to take seriously. The criticism however led also to criticism of TGD identification of qualia [K59] and much simpler identification involving only the basic assumptions of ZEO based quantum measurement theory emerged. Occam's razor does not leave many options in this kind of situation.

IIT predicts panpsychism in a restricted sense as does also TGD. The identification of maximally integrated partition of elementary system endowed with mechanism, which could correspond to computer program, to two parts as conscious experience is rather near to epiphenomenalism since it means that consciousness is property of physical system. In TGD framework consciousness has independent causal and ontological status. Conscious existence corresponds to quantum jumps between physical states re-creating physical realities being therefore outside the existences defined by classical and quantum physics (in TGD classical physics is exact part of quantum physics).

7.2 Critical Summary of IIT

Tononi starts from neuroscience and information theory. Information theoretic approach has the virtue that can avoid sticking into the dogmas of existing philosophy. Tononi and Koch emphasize that IIT tries to axiomatisize the essential aspects of consciousness so that physical theories of consciousness could start from this picture. Concerning the definition of information the starting point is classical probability theory.

One can criticize this view. Quantum physics provides extremely non-trivial new view about physical existence that it seems almost impossible to comprehend by organisms at our evolutionary level. Quantum measurement theory - the poorly understood part of quantum theory - forces to ask fundamental questions about the nature of consciousness, which suggests that neglecting it can mean a fatal loss of information. Quantum information theory is rapidly developing and should be highly relevant for any theory of consciousness starting from the notion of information. IIT's integrated information Φ is also a measure for complexity. Quantum theory provides a vision about complexity based on quantum entanglement. Also quantum biology has emerged as a new branch of science.

Information, integration and conceptual structure are basic notions introduced by Tononi. All these notions are poorly understood in standard physics framework. Also the notion of elementary mechanism is introduced. Mechanism could correspond to computer program or asequence of neural associations or formation of self-organization pattern. Elementary mechanisms can be combined to more complex mechanisms and these into systems of mechanisms. Mechanism can be identified as time evolution of some kind and has has inherent time arrow associated with it.

As the title "Consciousness, here, there, and everywhere" of [J90] expresses, panpsychism is adopted in IIT in the form that consciousness can be a property of any material system. For this reason the approach of Tononi is regarded by Horgan as an extremely ambitious approach certainly it is so from the perspective of neuroscience. For a physicist taking consciousness seriously panpsychism in some sense is the only possible option and predicts hierachy of conscious entities.

This panpsychism does not mean that everything is conscious but that everything can be conscious. The criterion for this is that integrated information is large enough. This roughly means that system is coherent structure such that information cannot be localized to its part.

7.2.1 Information

The key vision is that conscious experience carries information and that this information is integrated in the sense that parts of experience give information of each other: one might say that conscious information defines a rule $A \rightarrow B$. In neuroscience association would be the counterpart for this. This relationship need not be strictly causal but is as near to causal as possible.

In quantum theory entanglement could realize the strong correlation: now one however knows the state of the entire system but has very little information about the states or parts.

A mechanism can contribute to consciousness only if it specifies "differences that make differences" within a system. This sounds rather fuzzy statement. A slightly clearer manner to say this is that a mechanism generates information only if it constrains the states of a system than can be its possible causes and effects. One speaks of cause-effect repertoire. An even clearer identification of mechanism is as a dynamics of some kind.

In biology one could interpret cause-effect repertoire as a counterpart of a biological function assigning to sensory input a a motor output. In neuroscience mechanism could correspond to a sequence of associations defined by nerve pulse patterns or a behavior assigning a motor response to a given sensory input. Mathematician could speak of function. Physicist could speak of time evolution - say classical or self-organization. In computational science one could interpret Boolean functions or computer programs as mechanisms. The obvious criticism is that one can imagine endless variety of mechanisms and the theory loses its predictive power.

For a mechanism leading from a state of A to that of B information could be defined mathematically as $I(A \rightarrow B) = H(B|A) - H(A)$ by subtracting from conditional entropy for output associated with probabilistic input the entropy of the input. The information serves a measure for the reduction of ignorance and one cannot speak of ignorance without assuming a conscious entity able to interpret the output. This kind of notion in the definition of conscious information implies circularity.

One of the predictions is that feedback in the dynamics of mechanism is necessary for consciousness. Intuitively feedback means self-control characteritizing living systems (homeostasis). It is known that system theoretically a system with feedback can be approximated with a more complex system with only forward feedback. A system with/without feedback could/would be conscious/zombie. The theory would not therefore be behavioristic. Also rather simple non-living systems with feedback could be conscious.

I must admit that I did not quite understand why feedback is necessary for consciousness. If one defines information assignable to mechanism as sum $I(A \to B) + I(B \to A)$ then it is is easy to understand the importance of feedback. For instance, if the output depend only weakly of the input as in self-organizing systems without feedback (all irrelevant details are polished away in thermal non-equilibrium state), I(B|A) would be very small and the criterion for cause-effect relationship would not be satisfied. Feedback changes the situation.

7.2.2 Integration

Intuitively it seems that intelligent systems consist of highly correlated parts but that the correlation cannot be too high (completely random system carries no information and spontaneously magnetized systems carries just one bit of information). To noni introduces a measure $-\Phi$ - that he calls integrated information that would serve as a measure for this property measuring the level of consciousness.

This suggests that a mechanism can contribute to consciousness only if it specifies a causeeffect repertoire that is irreducible to independent components. The irreducibility of experience means that the experience cannot be reduced to parts. A more comprehensible statement is that information contained by system cannot be localized to any art of it. Here one can criticize: mental images could be seen as rather independent parts of experience.

Tononi speaks of integrated information defined in terms of maximum of relative entropy (see http://tinyurl.com/hazmflc). Scott Aaronson represents a rather comprehensible definition.

1. One wants a concrete measure for the interdependence of the subsystems A and B defining partition of the system. The integrated informations should correspond to maximally interdependent partition. The measure for integrated information - call it Φ - must have a maximum Φ_{max} if A and B are in causal relation. Φ is obtained by maximizing over all divisions of system to two parts A and B some measure of the sum of mutual informations definable in terms of conditional entropies assuming that the states in either A or B are random. Conditional entropy is entropy H(A|B) - H(B) and if A and B are strongly correlated is negative and has interpretation as information. FIn the case of brain, left and right hemispheres are natural candidates for maximally integrated pair (A,B) and one could understand left-/right- hemisphere dominance as a failure of integration.

These entropies are associated with mechanism, which translates to a function mapping the states of the entire systems to its states. The maximizing pair (A,B) would define the maximally causal relationship and give rise to a building brick of experience deserving to be called quale. This definition of quale is to my opinion rather ad hoc. The introduction of the mechanism brings in so many subjective assumptions that the definition might not have practical value. There are also difficulties related to the estimation of maximally integrated subsystem and thus of Φ_{max} : this might represent problem in NP class.

- 2. A measure for complexity is in question and numerous measures for complexity has been introduced by mathematicians. Φ would be a measure for feedback between and interdependence of different parts of the system. When Φ is above critical value, system is conscious. Intuitively, if the parts of the system are not correlated and communicating, system is not conscious. Even proton could be conscious since quarks are strongly correlated although it is questionable whether it makes to sense to talk about feedback in this context. In any case, this looks rather reasonable. $\Phi_{max} = 0$ means that system is completely reducible into its parts. The problem is that the connection with fundamental physics is lacking. Φ_{max} would measure the level of consciousness. I do not know how Φ_{max} would be measured and probably no one knows.
- 3. Aaronson gives a concrete example giving a gist about what integrated information could means. He also demonstrates that the definition of Tononi leads to technical problems using his identification of mechanism as a map of states of system to states of system. This could be of course quite too limited definition.

The idea is to consider all partitions of the system to two parts A and B. One can consider a system consisting of a ordered set of points to which one can assign finite number of states. Also binary digits could be considered. The states in set A are assumed to be random.

To identify the partition giving rise to maximal integrated information, one calculates the relative entropies for the images of the points and identifies integrated information as their sum. One can do the same by regarding the states assignable to points of B as random. One sums the relative entropies. If there is strong correlation between A and B then the randomness in A implies that this sum is large. If there is no dependence between A and B the sum vanishes. The partition (A,B) for which the sum of entropies is minimal corresponds to the partition defining the decomposition, which can define cause-effect pair. Integrated information is assigned with this pair.

4. Aaronson's first objection relates to the difficulty of identifying of the connection network of brain. One does not even idea about how to identify the nodes of this network. Neurons in state 1 or 0 is hardly suggested by anyone nowadays. Should one try to reduce to microtubular level. Or perhaps to the level of DNA and proteins? The identification of mechanisms as analogs of functions is a further heavy difficulty. Do their correspond to analogs of classical computer programs or to sequences of associations? Aaronson also thinks that panpsychism is unacceptable. To my view this particular criticism cannot be taken too seriously.

Consciousness can be present even when neural activity is low as in meditative states and IIT can explain also these states. What matters is the degree of integration - not so much the input. This leads to ask whether a closed system without sensory input and metabolic feed can be conscious. IIT says makes no obvious statements about the role of metabolism. IIT is also silent about the social aspects of consciousness and reduces consciousness to the properties of a network.

The assumption that the decomposition (A,B) corresponding to maximally integrated information as characterizing the contents of consciousness is to my opinion very problematic. Information is a relative notion: only a conscious system can have information about something. One therefore defines consciousness as an aspect of conscious experience so that the definition is circular. Second problem is that information as also consciousness is always about something unlike matter which such exists. Information as independent "substance" makes no sense.

Standard physics allows only to speak about entropy characterizing the lack of information about the state of system. When intelligent entity learns what the state of system is it receives information equal to this entropy. Here however the notion of conscious experiencer leaks in! The assignment of information to a bit sequence assumes that there is system for which the bit sequence has meaning by generating a process leading to a conscious experience interpreted as understanding. I dare guess that for my cat (or even for standard man in the street) these lines carry absolutely no information. Thus the dream about measuring information as a physical observable and concluding from this whether system is conscious and what the level of consciousness is, fails. The identification of Tononi leads to the notion of consciousmeter. To me this notion crystallizes what goes wrong with the physicalistic and purely information theoretic approaches.

To make the criticism more precise, one can look at the expression for I(A, B) = S(A|B) - S(B) with conditional probabilities defined by p(A|B) = p(A, B)/p(B). If A and B are independent events that is if the output has no correlation with input as in the case of thermodynamical system, one has $p(A, B) = p(A) \times p(B)$ and one has I(A, B) = S(A) - S(B). Second law tells that the information is negative. In thermal equilibrium I(A, B) = 0. Quite a reasonable result.

Intuitively optimal situation is achieved when S(A|B) having interpretation as the entropy associated with the causal evolution is zero: evolution would be completely deterministic as in classical computer programs or quantum computer programs during computation. Therefore classical computer programs, which do not map two inputs to same output would be ideal (the error correction program mentioned by Scott Aaronson) as far as consciousness is involved: this is not surprising taking into account the idea about neuron as bit.

The situation would be optimal for the maximally entropic initial state: this looks admittedly strange. Printing of a page of text about whose content I know nothing would be a highly conscious process! If I knew the content of the page, it would not be a conscious process! Obviously this is true but for me, not the system claimed to be conscious! The circulatory definition of conscious information leads to this non-sensical result. All definitions of conscious information based on Shannon entropy lead to the same result. One must have genuine definition of information.

These are classical considerations. Could this paradoxical situation make sense quantally or in TGD framework? Conscious entity - self - would live in adelic world and would be negentropically entangled subsystem - superposition of several state pairs. By NMP in Zero Energy Ontology implying self as generalized Zeno effect it would not allow state function reduction during its lifetime so that outsider could not learn what it's state is!

Real entanglement entropy would describe this missing information and the sum of p-adic negentropies the conscious information possessed by the self (for rational entanglement probabilities these two measures would have the same value). In TGD inspired theory of consciousness the paradoxical statement would thus make sense! Schrodinger cat remains conscious as long as no-one is able to measure the state of cat (note that here dead-alive dichotomy as a metaphor is not good). Conscious systems are secretive!

7.2.3 Architecture of consciousnes

Exclusion

Exclusion means that a mechanism can contribute to consciousness at most one cause-effect repertoire. This repertoire has maximum value of integration/irreducibility Φ_{max} . Exclusion is taken to mean that although subsystems of brain can have large Φ the entire brain masks their contribution to conscious experience. The masking postulate looks rather strange but is necessary unless one assumes hierarchy of consciousness so that subconscious would correspond to conscious but not at our level of hierarchy. Not all brain activity would be conscious to us. The activities of brain regions such as cerebellum are regarded as unconscious although there are more neurons there than in cortex. It could be that cerebellum is only unconscious to us?

Composition of mechanisms and conceptual structure

It is also possible to compose mechanisms. This is analogous to the composition of functions or formation of network from modules defining elementary functions. Composition can be also in time domain - say as a sequence of program modules as in computer program - so that the spatial realization is not changed. Composition is also analogous to what engineer is doing when he constructs more complex structures from primitive ones or programmer builds more complex programs from simple basic modules. This principle is very clearly present in biology and neuroscience based notion of conceptual structure.

The above postulates apply also to systems of mechanisms obtained by composition. This defines a conceptual structure identified as a constellation of points in concept space, where each axis consists of past/future state of the set of elements, and each point is a concept specifying differences that make a difference within a set. The higher the number of different concepts and Φ_{max} value, the higher the conceptual information.

Conceptual structure is kind of network build from mechanisms and analogous to a composition of functions or of computer programs. From the definitions it seems clear that conceptual structure does not correspond to independent ontological level in any sense. Conceptual structure should determine qualia and intensity of conscious experience. Here physicist starts to shake his head. I find it very difficult to imagine that qualia could be reduced to a structure of a network diagram. The unsuccessful attempts to identify qualia in terms of neural networks have demonstrated this (it is not possible to demonstrate any difference between the structure of neural networks in various sensory areas nor in the structure of sensory pathways).

The partial reduction of consciousness to mechanisms is in accordance with the idea about brain as computer. In this framework imagination might perhaps be understood as motor actions stopped before becoming real. Virtual sensory inputs which do not begin from sensory receptors is interpretation in the case of sensory experiences. They might have also this aspect but there might be something deeper distinguishing between imagination and reality.

Identity postulate

One of the axioms states that consciousness exists. Something rather trivial. But does this mean that consciousness exists as something reducing to matter/physics as we know it. This is the crucial question distinguishing between monistic and dualistic and possible other theories.

One of these dogmas manifests in the question "dualistic or monistic" inspired by the belief that no other options are possible (TGD represents such an option). Tononi answered the question whether IIT is materialistic or dualistic theory of mind cryptically by saying "IIT is what IIT is". On the other hand, the proposal of consciousmeter could come only from a physicalist and physicalism reduces consciousness to an epiphenomenon.

IIT resembles physicalistic/materialist approach in that it identifies consciousness with the decomposition of elementary system to a pair (A,B) of subsystems information measure Φ and selects a unique pair as that for which this information is maximal. I_{max} measures the intensity of conscious experience. To this pair one assigns experience. Thus experience corresponds to unique decomposition of system to two parts. The technical problem is that this decomposition need not be unique! In any case, the structure and dynamics of system defined by mechanism would dictate completely the contents of consciousness.

Qualia

Qualia are assigned with the links of a net like structure. If I understand correctly, this structure corresponds to a collection of mechanisms with link identified as a mechanism connecting members of a causal pair. One assigns to link an information as relative entropy defines as the difference of entropies of the network and network without the link.

Why the link should carry say sensory quale remains a mystery to me. I would be ready to accept that the structure of experience corresponds to a network but assigning qualia with the links does not look like a feasible idea. It remained unclear to me whether qualia space corresponds to the links of the network or whether it corresponds to a collection of the networks. For instance, it is not easy to understand how basic colors could be understood in his framework. What properties

of the link identified as mechanism or its relationship to the rest of the network could make the color quale "red" instead of "green".

7.3 TGD inspired theory of consciousness as quantum measurement theory in ZEO

To make the comparison easier for the reader I first summarize very briefly the basic ideas of TGD inspired theory of consciousness identified as quantum measurement theory in zero energy ontology (ZEO).

7.3.1 Zero Energy Ontology (ZEO)

ZEO [K85] was motivated by TGD inspired cosmology. Physical states have vanishing conserved net quantum numbers and are decomposable to positive and negative energy parts. The particle physics interpretation is as initial and final states of a particle reaction. A profound modification of existing views about realization of symmetries is in question.

The notion of causal diamond (CD) is closely related to ZEO. CD corresponds to an intersection of past and future directed light-cones of Minkowski space (with points replaced by CP_2). Positive and negative energy parts of physical states are at future and past boundaries of CD which form part of light-one. Poincare transforms of CDs are allowed and CDs for a fractal hierarchy. A number-theoretically attractive hypothesis is that the distance between the tips of CD is quantized essentially as multiple of the size scale CP_2 . CD can be interpreted as the 4-D perceptive field of conscious entity: zero energy state corresponds to a superposition of space-time surfaces having their ends about light-like boundaries of CD.

S-matrix and density matrix are unified to the notion of M-matrix defining time-like entanglement and expressible as a product of square root of density matrix and of unitary S-matrix. At least formally, thermodynamics becomes therefore a part of quantum theory, which can be regarded as "complex square root" of thermodynamics. One has kind of thermodynamical holography in the sense that square roots of thermal ensembles are realized at single particle level. One must distinguish M-matrices identifiable as products of orthonormal hermitian square roots of density matrices and universal S-matrix from U-matrix defined between zero energy states and analogous to S-matrix and characterizing the unitary process associated with quantum jump. The detailed description of U- and M-matrices is considered in [K85].

The most dramatic ontological implication is that quantum jump sequence can in principle lead to any zero energy state: this allows to avoid many unpleasant paradoxes forcing theorist to wonder whether theories are needed at all (in deterministic context only single solution of field equations is realized!). ZEO is consistent with the basic laws of quantum physics, allows maximal free will, and allows to solve the basic paradoxes of quantum measurement theory (determinism viz. non-determinism paradox and problems with the notion of time).

7.3.2 Hierarchy of Planck constants and dark matter hierarchy

One motivation for the hierarchy of Planck constants came from neuroscience from the observations made by Blackman and other pioneers of bio-electromagnetism [J23] [K120]. The observations could be summarized by saying that electromagnetic radiation of vertebrate brain at ELF frequencies (say multiples of 15 Hz) has both physiological and behavioral effects, which also look quantal. Quantal character is in conflict with the fact that ELF frequencies correspond to photon energies E = hf, which are extremely low, something like 10 orders of magnitude below thermal at physiological temperature. This inspired the proposal that photons are dark in the sense that for them one has $h_{eff} = n \times h$.

The identification of dark matter as phases having large value of Planck constant [K117, K55, K47] led to a vigorous evolution of ideas. Entire dark matter hierarchy with levels labelled by increasing values of Planck constant coming as integer multiples $h_{eff} = n \times h$ of ordinary Planck constant is predicted. A further assumption was that the dark matter in question is at magnetic flux tubes of the magnetic body of living system or of its part. This leads to the identification of EEG as a communication tool from biological body to magnetic body (MB). MB
would receive sensory data from cellular and nuclear membranes and send control commands - most naturally via genome - to the biological body. MB would act as intentional agent using biological body as sensory receptor and motor instrument. This assumption allows to identify a long list of mechanisms used by magnetic body. Bio-photons can be understood as ordinary photons resulting when dark photons transform to ordinary ones [L28, K20].

The mathematical understanding of the hierarchy of Planck constants took a longer time [K55, ?]. The original vision was that the hierarchy of Planck constants demands a generalization of quantum TGD. This would have required a generalization of the causal diamond $CD \times CP_2$, where CD is defined as an intersection of the future and past directed light-cones of 4-D Minkowski space M^4 . It however became clear that the hierarchy of Planck constants labels a hierarchy of quantum criticalities characterized by sub-algebras of super-symplectic algebras possessing a natural conformal structure. The sub-algebra for which the conformal weights come as *n*-ples of those for the entire algebra is isomorphic to the full algebra and acts as a conformal gauge algebra at given level of criticality.

In particular, the classical symplectic Noether charges for preferred extremals connecting 3-surfaces at the ends of CD vanish - this defines preferred extremal property. There would be n conformal gauge equivalence classes of preferred extremals which would correspond to n sheets of a covering of the space-time surface serving as base space. There is very close similarity with the Riemann surfaces. Therefore coverings would be generated dynamically and there is no need for actual coverings of the embedding space.

The gauge degeneracy corresponds to the non-determinism associated with the criticality having interpretation in terms of non-determinism of Kähler action and with strong form of holography. The extremely strong super-symplectic gauge conditions would guarantee that the continuation of string world sheets and partonic 2-surface to preferred extremals is possible at least for somes value of p-adic prime. A good guess is that this is the case for the so called ramified primes associated with the algebraic extension in question at least. These ramified primes would characterize physical system and the weak form of NMP would allow to understand how p-adic length scale hypothesis follows [K142]. The continuation could be possible for all p-adic primes due to the possibility of p-adic pseudo-constants having vanishing derivative. It could quite well happen that the continuation fails for most configurations of partonic 2-surfaces and string world sheets in the real sector: the interpretation would be that some space-time surfaces can be imagined but not realized [K88]. For certain extensions the number of realizable imaginations could be exceptionally large. These extensions would be winners in the number theoretic fight for survivalandcorresponding ramified primes would be preferred p-adic primes.

A further strong prediction is that the phase transitions increasing h_{eff} and thus reducing criticality (TGD Universe is like hill at the top of the hill at...) occur spontaneously [?]. This conforms with NMP and suggests that evolution occurs spontaneously. The state function reduction increasing h_{eff} means however the death of a sub-self so that selves are fighting to stay at the criticality. The metabolic energy bringing in negentropic entanglement (NE) allows to satisfy the needs of NMP so that the system survives and provides a garden in which sub-selves can are born and die and gradually generate NE. Living systems are thus negentropy gatherers and each death and re-incarnation generates new negentropy.

All particles in the vertices of scattering diagrams have the same value of Planck constant so that the particles at different pages cannot have local interactions. Thus one can speak about relative darkness in the sense that only the interactions mediated by the exchange of particles and by classical fields are possible between different pages. Dark matter in this sense can be observed, say through the classical gravitational and electromagnetic interactions. It is in principle possible to photograph dark matter by the exchange of photons which leak to another page of book, reflect, and leak back. This leakage corresponds to h_{eff} changing phase transition occurring at quantum criticality and living matter is expected carry out these phase transitions routinely in bio-control. This picture leads to no obvious contradictions with what is really known about dark matter and to my opinion the basic difficulty in understanding of dark matter (and living matter) is the blind belief in standard quantum theory. These observations motivate the tentative identification of the macroscopic quantum phases in terms of dark matter and also of dark energy with gigantic "gravitational" Planck constant [?, K95].

The construction gives also the 4-D space-time sheets associated with the light-like orbits of the partonic 2-surfaces: it remains to be shown whether they correspond to preferred extremals of Kähler action. The hierarchy of Planck constants has become an essential part of the construction of quantum TGD and of mathematical realization of the notion of quantum criticality rather than a possible generalization of TGD.

7.3.3 p-Adic physics as physics of cognition and imagination

During years it have become more and more clear that consciousness involves cognition in an essential manner.

Extension of real physics to adelic physics

In TGD framework cognition is described in terms of p-adic number fields and has led to a fusion of real and various p-adic physics to what I call adelic physics [K142]. Real physics corresponds to sensory experience and p-adic physics to cognition and imagination. Originally I talked about p-adic physics of cognition and intentionality but I have dropped intentionality away since I am not quite certain.

The difficult question has been how real and p-adic physics relate to each other. The naïve idea is that rationals belong to the intersection of reals and p-adics. More generally, points in algebraic extension of rationals would be common to realities and p-adicities which correspond to "thought bubbles" or imaginations. This hierarchy defines a hierarchy of adeles having interpretation in terms of evolution leading to increasingly complex algebraic extensions of rationals.

The first guess was that this means at space-time level that embedding space points with rational valued coordinates (or values in the extension of rationals) correspond to common points of real and p-adic space-time surfaces. This picture however leads to problems with both general coordinate invariance and key symmetries of TGD. What are the preferred coordinates of space-time surface which would be in algebraic extension of rationals in the intersection? Should one restrict symmetry groups to their discrete subgroups?

The resolution of the problem came from the realization that the intersection of realities and p-adicities corresponds to space-time surfaces, whose representation is such that they make sense both in real and p-adic sense. This requires that the WCW coordinates of these surfaces are invariant under various symmetries and general coordinate transformations of space-time belong to the extension of rationals in question. At the level of WCW the coordinates are highly unique on basis of symmetries and by general coordinate invariance at space-time level. This also means discretization of the infinite-dimensional WCW and together with huge isometry group of WCW gives hopes about computatibility of TGD.

Negentropic entanglement

In given p-adic sector the EE is defined by replacing the logarithms of probabilities in Shannon formula by the logarithms of their p-adic norms. The resulting entropy satisfies the same axioms as ordinary entropy but makes sense only for probabilities, which are rational valued or in an algebraic extension of rationals. The algebraic extensions corresponds to the evolutionary level of system and the algebraic complexity of the extension serves as a measure for the evolutionary level. p-Adically also extensions determined by roots of e can be considered. What is so remarkable is that the number theoretic entropy can be negative.

A simple example allows to get an idea about what is involved. If the entanglement probabilities are rational numbers $P_i = M_i/N$, $\sum_i M_i = N$, then the primes appearing as factors of Ncorrespond to a negative contribution to the number theoretic entanglement entropy and thus to information. The factors of M_i correspond to negative contributions. For maximal entanglement with $P_i = 1/N$ in this case the EE is negative. The interpretation is that the entangled state represents quantally concept or a rule as superposition of its instances defined by the state pairs in the superposition. Identity matrix means that one can choose the state basis in arbitrary manner and the interpretation could be in terms of "enlightened" state of consciousness characterized by "absence of distinctions". In general case the basis is unique.

Metabolism is a central concept in biology and neuroscience. Usually metabolism is understood as transfer of ordered energy and various chemical metabolites to the system. In TGD metabolism could be basically just a transfer of NE from nutrients to the organism. Living systems would be fighting for NE to stay alive (NMP is merciless!) and stealing of NE would be the fundamental crime.

TGD has been plagued by a longstanding interpretational problem: can one apply the notion of number theoretic entropy in the real context or not. If this is possible at all, under what conditions this is the case? How does one know that the entanglement probabilities are not transcendental as they would be in generic case? There is also a second problem: p-adic Hilbert space is not a well-defined notion since the sum of p-adic probabilities defined as moduli squared for the coefficients of the superposition of orthonormal states can vanish and one obtains zero norm states.

These problems disappear if the reduction occurs in the intersection of reality and p-adicities since here Hilbert spaces have some algebraic number field as coefficient field. By SH the 2-D states states provide all information needed to construct quantum physics. In particular, quantum measurement theory.

- 1. The Hilbert spaces defining state spaces has as their coefficient field always some algebraic extension of rationals so that number theoretic entropies make sense for all primes. p-Adic numbers as coefficients cannot be used and reals are not allowed. Since the same Hilbert space is shared by real and p-adic sectors, a given state function reduction in the intersection has real and p-adic space-time shadows.
- 2. State function reductions at these 2- surfaces at the ends of CD take place in the intersection of realities and p-adicities if the parameters characterizing these surfaces are in the algebraic extension considered. It is however not absolutely necessary to assume that the coordinates of WCW belong to the algebraic extension although this looks very natural.
- 3. NMP applies to the total EE. It can quite well happen that NMP for the sum of real and p-adic entanglement entropies does not allow ordinary state function reduction to take place since p-adic negative entropies for some primes would become zero and net negentropy would be lost. There is competition between real and p-adic sectors and p-adic sectors can win! Mind has causal power: it can stabilize quantum states against state function reduction and tame the randomness of quantum physics in absence of cognition! Can one interpret this causal power of cognition in terms of intentionality? If so, p-adic physics would be also physics of intentionality as originally assumed.

A fascinating question is whether the p-adic view about cognition could allow to understand the mysterious looking ability of idiot savants (not only of them but also of some greatest mathematicians) to decompose large integers to prime factors. One possible mechanism is that the integer N represented concretely is mapped to a maximally entangled state with entanglement probabilities $P_i = 1/N$, which means NE for the prime factors of P_i or N. The factorization would be experienced directly.

One can also ask, whether the other mathematical feats performed by idiot savants could be understood in terms of their ability to directly experience - "see" - the prime composition (adelic decomposition) of integer or even rational. This could for instance allow to "see" if integer is say 3rd - power of some smaller integer: all prime exponents in it would be multiples of 3. If the person is able to generate an NE for which probabilities $P_i = M_i/N$ are apart from normalization equal to given integers M_i , $\sum M_i = N$, then they could be able to "see" the prime compositions for M_i and N. For instance, they could "see" whether both M_i and N are 3rd powers of some integer and just by going through trials find the integers satisfying this condition.

Strong form of holography and p-adic view about imagination

A further step in the progress came from the discovery of strong form of holography (SH) [K38]. 2dimensional surfaces (string world sheets and partonic 2-surfaces) are fundamental objects and 4-D physics is a kind of algebraic continuation from this intersection of reality and various p-adicities in both real and p-adic sectors of the adelic Universe. 4-D space-time surfaces are preferred extremals of Kähler action making them effectively 2-D in the sense that the 2-D surfaces serve as space-time genes. Also the quantum states assignable to the 2-D surfaces can be algebraically continued to the entire 4-D space-time. It is however quite possible that the continuation in the real sector to a preferred extremal of Kähler action fails. In p-adic sectors the possibility of p-adic pseudo constants which are piecewise constant functions with vanishing derivative makes the continuation much easier. This inspires the idea that imagination corresponds to these p-adic continuations. p-Adic continuation might be possible whereas real continuation could fail: one would have imagined world, which cannot be realized as often happens!

7.3.4 Quantum measurement theory in ZEO

NE is key notion and entanglement negentropy identified as number theoretic entanglement entropy (EE), which can be negative, takes in some sense takes the role of Φ serving as a measure for integrated information of TGD to be discussed below. NE can only increase in state function reductions and this brings in evolution forced by NMP. This leads to a precise identification for the notion of self, allows to understand the relationship between subjective time and geometric time, and even what life and death of a conscious entity mean. Here only the key aspects are listed.

- 1. Causal diamond (CD) is a central notion in ZEO and serves as embedding space correlate for self. State function reduction can occur to either boundary of CD ("upper" or "lower"). Self can be seen as a generalized Zeno effect a sequence of state function reductions to either boundary of CD. These two kinds of selves can be said to be time reversals of each other. The period of non-boiling pot corresponds to the passive boundary of CD not changing in the reductions: also the parts of zero energy states at this boundary remain unaffected. The opposite active boundary is shifted towards future reduction by reduction and states at it are changed. The shifting the geometric future gives rise to the experienced time flow. This is the analog of unitary time evolution.
- 2. One possibility is that sensory input and mental images ("Maya") generated by it can be assigned with the active boundary of CD. A more elegant assumption suggested by quantum measurement theory is that the passive boundaries for sub-CDs give rise to mental images as outcomes of repeated quantum measurements. The unchanging part of self ("Self") is associated with the passive boundary. It corresponds to negentropically entangled subsystem having no entanglement with environment. In ordinary ontology it would not be possible keep self un-entangled from the environment.
- 3. NMP forces eventually the first state function reduction to the opposite boundary of CD: the pot starts to boil. Self dies and re-incarnates as time reversed self at the opposite boundary. The life-time of self is measured as the increase of the temporal distance between the tips of CD. Time reversed self evolves as reductions shifting the opposite boundary of CD to opposite time direction so that the size of CD continues to increase and defines a measure for the duration of the entire sequence of re-incarnations. This implies quantum physical realization for the idea about transmigration of souls! Excellent manner to get rid of street-credibility is to tell to academic audience about this implication.
- 4. One big news is that selves form a hierarchy (CDs within CDs) and sub-selves are identified as mental images. In TGD framework it is also possible for sub-selves of two unentangled selves to entangle negentropically. This corresponds to sharing of mental images and means that our conscious experience is not completely private. The pool of shared mental images might in fact make possible communication and social structures. Sharing of mental images is possible only in many-sheeted space-time forcing to generalize the standard view about subsystem.

The divisions of system to two parts are involved with the definition of integrated information. Also in the formulation of NMP in terms of maximal negentropy gain one considers divisions of the system into subsystem and complement and finds the pair for which the reduction of entanglement would give maximum reduction of entropy. If the system is irreducible this kind of pair characterized by entropic entanglement cannot be found. The eigenstates of density matrix for negentropically entangled subsystems are in 1-1 correspondence. An interesting question is whether associations in the sense of neuro science corresponds to NE between the states of associated systems. State function reduction scade is also key notion. State function reduction sequences is a top down cascade propagating downwards to smaller system sized. First the reduction in CD scale occurs. The resulting two subsystems decompose to two parts and so on untile decomposition is not possible anymore because it would not generate negentropy.

7.3.5 TGD view about qualia

The TGD inspired theory of qualia [K59] has evolved gradually.

- 1. The original vision was that qualiaandother 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 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 di-electric breakdown [K80] 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 di-electric breakdown generates Bose-Einstein condensate and the quantum numbers for the BE condensate give rise to qualia assignable to sub-self.

7.4 Comparison of IIT with TGD

7.4.1 Basic concepts of IIT from TGD point of view

Pan-psychism, identity postulate, and physicalism from TGD viewpoint

In TGD framework panpsychism is assumed but in different form. Consciousness is not a property of matter unlike in IIT but an independent form of existence not reducible to say geometric existence so that notions like qualia space introduced in IIT do not make sense. Consciousness is the state function reduction occurring between different material worlds. This resolves the fundamental problems related to quantum measurement theory and the notion of time. In ZEO one can talk about conscious entities (this is almost unavoidable since our language reflects the belief that consciousness is a property of physical system) as internally negentropically entangled systems de-entangled from the rest of the world at the possive boundary of CD. In standard quantum theory this would make no sense. All qualia would correspond to outcomes of repeated quantum measurements at passive boundaries of sub-CDs of CD and defining mental images. The flow of time would correspond to contribution from the active boundaries of CDs involved.

Causal networks and the assignment of qualia to the links of the causal network

Causal network is assumed with motivations coming from neuroscience and qualia are assigned with the links of this network. They would correspond to axons or neural pathways in neuroscience.

Criticism:

- 1. The idea that various sensory qualia could be understood in terms of topological structure of a network formed by neuronsandaxons is old but has not led to the understanding of qualia. The neural network looks exactly the same in various sensory areas. Also the sensory pathways looks the same.
- 2. Causal interactions between parts of brain are assumed to give rise to consciousness. People having no corpus callosum have synchronous left and right hemispheres [J57] (see http://tinyurl.com/3gjhtgb)! One might expect that causal interactions between hemispheres must be responsible for the synchrony but it is difficult to imagine anything like this now. There seems to be something like "boss" forcing both hemispheres to synchrony.

In TGD the qualia correspond to the eigenvalues assignable to the observable measured during repeated state function reductions leaving the states at passive boundary of sub-CDs representing mental images of self invariant. Non-locality and new view about time allows to consider also the possibility that qualia can be assigned with the sensory organs. One cannot of course exclude the possibility that also neurons can have primary sensory experiences rather than just sharing the primary sensory mental images assignable to the sensory organs.

In TGD framework the networks emerge naturally as networks of magnetic flux tubes [L54].

- 1. The "boss" forcing the synchrony of disconnected left and right hemispheres would be magnetic body (MB) of brain [L57]. Magnetic bodies appear in all scales. NE between nodes of this network is what is more significant.
- 2. The so called tensor networks [B15] [L51] (see http://tinyurl.com/y9kwnqfa), which have emerged as realizations of error correction codes in quantum computation and realize holography can be seen as a realization of NE. The realization in terms of magnetic flux tubes could define kind of template for the dynamics of bio-systems. Magnetic body (MB) would define both geometric and dynamical template for bio-chemistry and even genetic code could be reduced to this level. MB would complete the organism-environment duality to trinity.
- 3. The dynamics of MB (motor actions of MB as reconnections, contractions of flux tube, changes of the topology of the network inducing NE transfer) and also the dynamics at MB (supra currents, dark photons propagating along flux tubes in targeted manner) would define the analog for the causal dynamics appearing in IIT. ADP-ATP transition attaching phosphate to ADP has interpretation as transfer of NE. Phosphate-X (X some large system) flux tube is attached to ADP to give ATP-X NE and when ATP gives phosphate to biomolecule Y one obtains Y-X NE (for what Y could be, see below). Metabolic energy could go basically to transfer NE between systems. This would mean that the local dynamics of the network would be central for what it is to be living.
- 4. This picture would suggest that the changes of topology making possible transfer of negentropy are crucial for consciousness in living systems. Dynamics of bits in static networks represents only the classical communications associated with genuinly quantal system.

Bio-photons identified as decay products of dark photons with large value of Planck constant h_{eff} is an essential element of resonant like precisely targeted communications along flux tubes of MB. It must be made clear that TGD has had an interpretational problem related to the identification of bio-photons as decay products of dark protons [?, K95]. The resolution of this problem leads to conclusion that MBs with field strengths assignable to Earth's *resp.* galactic magnetic fields control living matter and have EEGs related by scaling: for details see [L54].

What the mysterious looking entity X could then be? The MB of Earth assignable with Earth's mass via $\hbar_{eff} = \hbar_{gr} = GMm/v_0$ is the first candidate for X but for it EEG would be scaled down since the flux tubes would correspond to those of galactic magnetic body with $B_{gal} \sim 10^{-9}$ Tesla: 10 Hz alpha band would correspond to 72 minute time scale and natural periodicity would be given by sidereal day. Spottiswoode observed that sidereal day defines periodicity for precognition [J78]. A mass $M_D \simeq 5.\times^{-5} M_E$ forming a spherical layer at the distance of Moon from Earth associated with the magnetic Mother Gaia controlling bio-dynamics would correspond to the ordinary EEG. This would also predict that 1 s cyclotron time for DNA sequences in $B_{end} = .2$ Gauss corresponds to 12 h cyclotron time for $B_{gal} = .63$ nT.

The presence of these two MBs be a dramatic manifestation of non-locality. These MBs would make life possible at Earth. Both MBs would be in continual contact with biomolecules like ATP and the molecules for which ATP attaches or provides the phospate. Metabolic energy would be used to this process. These MBs would be Goddesses directing their attention to tiny bio-molecules. If this picture is correct, the ideas about consciousness independent on material substrate and assignable to a running computer program can be safely forgotten.

The notion of integrated information (Φ) from TGD viewpoint

In TGD the analog of Φ as measure of complexity would be number theoretic entanglement negentropy involving p-adic norm in its definition. If defined as average for the entanglement negentropies for various partitions of the system to two parts it would define a measure for the complexity and correlations.

Formally a modification of Shannon entropy is in question but the surprise is that it can be negative in which case one has NE It makes sense for entanglement coefficients in algebraic extension of rationals: this predicts number theoretic evolutionary hierarchy of conscious entities. The definition relates closely to p-adic physics as physics of cognition. Number theoretic EE measures the information associated with NE (ordinary EE measures the lack of information about state of entangled system due to entanglement). The basic variational principles is NMP stating that the negentropy gain is maximal in each state function reduction. NMP forces the amount of NE measured by number theoretic entanglement negentropy to increase. One interpretation for the NE resources of the Universe is as "Akashic records". Universe would be a huge growing library of books formed by negentropic mental images.

In TGD framework the reduction of the system to its parts leading to a loss of consciousness would occur by state function reduction. NMP can prevent this in presence of cognition. That state function reductions occur rather often at elementary particle level tells that their cognitive level is rather low. Breaking of time reversal symmetry analogous to that in thermodynamics is also a signature of cognition.

The proposal about critical value of Φ makes the situation analogous to that in critical thermodynamical systems. This also brings in mind quantum criticality of TGD fundamental for the understanding of the evolution of conscious entities in TGD framework. It brings in the hierarchy of dark matter represented as phases of ordinary matter with non-standard value $h_{eff} =$ $n \times h$, n = 1, 2, ... of Planck constant emerging at quantum criticality and making macroscopic quantum coherence possible.

In TGD NE is a correlate for conscious information. NE also provides a correlate for integration. Conceptual structure could be assigned with the topological structure of NE, which would also be a correlate for complexity in quantum sense. Quantum computer people have indeed realized that the physics of complexity is essentially physics of entanglement. Conscious entity corresponds to the sequence of quantum jumps/reductions at fixed boundary of CD. Conscious entities have inherent NE and they are not entangled with environment. There is however no attempt to identify NE as consciousness.

The correlation produced by causal evolution in IIT is replaced with NE in TGD. Hence the two views look rather different as far as conscious information is considered. On the other hand, classical physics is exact part of TGD and quantum classical correspondence realized by strong form of holography (SH). Quantum computation accompanies self and quantum computation is accompanied by a quantum superposition of classical computations. Therefore one can ask whether the generalization of the formula for I(A, B) could be meaningful in TGD and even relate to consciousness.

- 1. In TGD framework the superpositions of classical space-time surfaces identified as preferred extremals connecting the positive and negative parts of zero energy states at opposite boundaries of CD define the counterparts of causal evolutions. Quite generally, classical deterministic evolution is highly analogous to a classical computer program.
- 2. The analog of I(A, B) in TGD could be assigned with the evolution zero energy state based on time evolution of the space-time surfaces: A and B would correspond to the positive and negative energy parts of states at opposite boundaries of CD (initial and final states of classical time evolution) defining self. B would correspond the passive boundary of CD

and A to the active boundary, which moves farther from B during the reduction sequence and states at it experience a discretized variant of unitary time evolution. The evolution for the active boundary of CD is the analog of unitary Schrödinger evolution and analogous to quantum computer program.

Note that in TGD framework quantum theory is purely classical theory formally! WCW spinor fields representing zero energy states are indeed purely classical spinor fields formally. Only state function reduction is something genuinely quantal.

- 3. S(A|B) could be interpreted as entropy generated by evolution analogous to classical computation. The time evolution however fails to be strictly deterministic and particle reactions represented topologically in terms of generalized Feynman diagrams would naturally relate to this non-determinism. Hence S(A|B) > 0 is expected to hold true and could be very much like entropy generated by particle decays and creation and the interpretation in terms of thermodynamics would be natural.
- 4. The very existence of self thus breaks second law (note however that state function reductions occur for sub-CDs assignable to mental images which die and are reborn). As self dies, thermodynamical entropy increases since this reduction is non-deterministic. On the other hand, new time-reversed self is born and carries NE and there is negentropy gain by NMP [K80]. Second law holds true in time scales longer than the life time of the long-livest self. I(A, B) > 0 could be thus assigned with selves during their life-time. Since the state function reduction to the opposite boundary of CD is non-deterministic, the conjecture that I(A, B) equals to negentropy gain in this reduction, does not make sense.
- 5. The definition of I(A, B) is non-trivial problem and discretization implied by finite measurement resolution at fundamental level is necessary in order to avoid mathematical difficulties in the case of deterministic evolution.

Counterparts of mechanisms and irreduciblity in TGD

Mechanism is central notion in IIT. In ZEO self organization patterns in 4-D sense serve as counterparts of behavioral patterns realizing causal relationship. Space-time surfaces identified as preferred extremals of Kähler action satisfying extremely powerful constraints coming from strong form of holography are space-time correlates for these self-organization patterns. System approaches reduction by reduction to these 4-D patterns: in positive energy ontology these patterns would be 3-D. This difference has profound implications.

The analog for the notion of irreducibility in TGD framework is that any subsystem at the passive boundary of CD is inherently negentropically entangled and remains so as long as the conscious entity lives and is in this sense irreducible at the passive boundary of CD. The information carried by NE cannot be localized.

Maximal NE defines isometric map between subsystem and its complement. In fact, the isometric map is possible for all subsystem complement pairs for so called perfect entanglement discussed by Preskill [B15] in his proposal for error correcting codes based on holography. This model has application in TGD inspired model of living systems based on the notion of magnetic body [L51].

NE is stable against NMP allowing state function reductions in which system splits into subsystem and complement is similar notion. Hilbert spaces with prime dimension are also irreducible in the sense the decomposition into tensor product of two subystems is not even possible and this might deeply relate to the fact that Mersenne primes seem to be very important in TGD [L61]. (see http://tinyurl.com/gp9mspa).

In TGD framework metabolism is not just feed of ordered energy but feed of NE carried by nutrients [K95, K68]. This NE means feeding in of connections to other system realized in terms of magnetic flux tubes and couple the system to environment and other conscious entities.

Self hierarchy makes exclusion postulate un-necessary

Exclusion postulate looks to me like the most problematic axiom of IIT. Hierarchy of selves with sub-system of system corresponding to sub-self makes exclusion postulate un-necessary in TGD

framework. System can have sub-systems conscious sub-systems and these in turn can have conscious sub-systems so that one has a hierarchy. The hierarchy of space-time sheets corresponds to this hierarchy at space-time level and the hierarchy of CDs at embedding space level. Subsystems correspond to mental images, which are kind statistical averages over mental images of sub-selves so that the information about lower levels is only statistical. This saves the system from drowning to irrelevant conscious informations.

Tononi does not consider the possibility of self hierarchy. Maybe the reason is that the idea about hierarchy of selves is central in spiritual practices involving angels and gods but is very difficult to accept in the western science accepting only what is directly perceived. In TGD framework the new space-time concept - in particular the notions of field body and magnetic body - support the notion of self-hierarchy. For instance, EEG could be seen as communications to the magnetic body of organism having onion-like structure with layers with sizes even larger than the size of Earth [K99, K98].

For instance, the damaging of cerebellum does not affect much consciousness. This is true but it is "our" consciousness, which is not affected - only one level in the self hierarchy. Cerebellum could quite well represent a level few levels below cortex in the hierarchy of selves. It can of course decompose to sub-structure, which are negentropically entangled but unentangled with each other.

This failure is reflected in the rather weird looking exclusion postulate. Parts of brain can have Φ allowing them to be conscious. Tononi cannot however make sense of this. The explanation would be that brain as a whole has so large a Φ that it overrides that for parts so that they are not conscious. By the same argument the Φ of Universe would be so large that there would be not a single conscious entity besides the entire Universe! One ends up with solipsism.

No variational principle of consciousness is introduced in IIT

In IIT no variational principle defining the dynamics of consciousness is introduced - say a postulate that the property measured by Φ would increase being therefore mathematically analogous to NMP in TGD framework. This kind of variational principle should imply evolution.

The definition of NMP involves quite refined number theoretic details but is consistent with standard quantum measurement theory and with standard measurement theory for ordinary entropic entanglement - that it is for ordinary matter. For dark matter one has NE and the situation changes. One can however say that second law for a given self holds true in time scales longer than the life-time of self.

NMP implies a kind of competition between subsystems, which can reduce their entanglement with environment in state function reduction. One can say that for a given system the state function reduction occurs for the subsystem-complement pair for which the reduction of EE is maximal. This if the entanglement is ordinary entropic entanglement, which is always reduces in accordance with the standard quantum measurement theory. For maximally negentropically entangled systems NMP need not lead to any effect. NE can be stable since as a whole it tends to increase. This does not prevent transfer of NE between systems.

The builder of consciousness theory is eventually led to ask about the origins of ethics and moral. NMP does not completely deterministically select the final state in the case of NE. For instance, if NE corresponds to $N \times N$ identity matrix it can happen that reduction occurs to a lower-dimensional space and one can speak of free will. The outcome can make the negentropy gain smaller but also larger. One can say that system has free will and even speak about ethics based on maximization of negentropy and moral choices. Complete reduction of entanglement would mean the worst possible deed and implies the system is de-entangled and thus isolated from the rest of the Universe.

7.4.2 Engineering aspect of consciousness

The idea that consciousness is engineered from simple building bricks is rather attractive and realized also in TGD framework.

The problematic notion of conceptual structure

The notion of conceptual structure is problematic in the sense that the assignment of qualia to the links of this structure does not look feasible. In TGD the combinatorial structure of NE the most natural TGD analog of conceptual structure. It would correspond in the most general case to a quantum superposition of networks - the so called spin liquid could actually realize this notion in condensed matter physics. Conscious entity would correspond to a sub-system having no entanglement with environment but its internal entanglement would be negentropic and maximal in well-defined sense. The notion of tensor network, which appears in quantum computations could be equivalent with the notion of negentropically entangled system. A quite recent proposal of Preskill [B15] is that error correcting quantum codes could be realized using tensor networks. This fits very nicely with TGD view [L51].

The structure of NE provides abstract backbone for the structure of conscious experience. The structure of NE does not however give any clue about qualia. In ZEO they can be assigned with either the passive of active boundary of CD. At active boundary they could be assigned with the quantum number transfer rates between the active part of self and environment. At passive boundary they would naturally correspond to the quantum numbers of the passive part of some sub-self at passive boundary of its CD: repeated measurement would give experience about what the quantum numbers are. This option would fit nicely with quantum measurement theory. If one interprets mental images as sub-selves, one can indeed understand why the sensory experiences vary from moment to moment although the passive part of self - "Self" - does not change.

The notion of conceptual structure unavoidably brings in mind p-adic physics as physics of cognition and imagination but these two notions should be distinguished. Adelic physics fuses real and various p-adic physics to single coherent role. To me this option looks much more plausible.

The problems of free will, intentionality, and time

IIT says nothing about volition, intentionality, and (not completely) free will. Mechanisms could be non-deterministic but this does not help much. To my opinion, trying to say something about free will leaves no other options than quantum theory or its generalization.

IIT says nothing about experienced time. Standard quantum measurement theory involves the notion of observer and is plagued by a deep paradox related to the determinism of Hamiltonian time evolution and non-determinism of quantum measurement theory. This has led to the Copenhagen interpretation depriving ontological status from the basic mathematical notions of quantum theory. The problem relates directly to the notion of observer, the question about reality of free will, and to the question about the relationship between the geometric time of physicist and the experienced time.

Obviously, non-conservative theorist cannot imagine more promising starting point for a theory of consciousness. One should generalize quantum theory so that one gets rid of paradoxes and provides a description of observer as conscious entity. In TGD framework the qualia can be reduced to fundamental physics, which to my opinion is much more convincing identification than the identification in terms of a particular partition associated with some mechanism assumed to be associated with the system considered.

The randomness of state function reduction does not resonate with the idea of intentional free will but it could be tamed by cognition making possible intentional free will made possible by the extension of real physics to adelic physics.

In principle ZEO allows also creation of any zero energy from vacuum state without any problems with the laws of physics. That this is impossible in positive energy ontology and is one of the main reasons for adopting the materialistic/physicalistic view about consciousness reducing it to epiphenomenon. It seems that the same reduction occurs in IIT.

TGD provides an elegant interpretation for the act of free will. Since nothing drastic happens during repeated state function reductions to the same boundary of CD, the act of free will can only corresponds to the first reduction to the opposite boundary of causal diamond (CD). The act of volition means the death of sub-self and reincarnation as time reversed sub-self. This explains the finding due to Libet that conscious decision to perform motor action (to raise finger) initiate neural activity before the decision. Negative energy signal to the geometric past of brain would initiate the neural activity.

A further outcome is that p-adic entanglement can be negentropic and by NMP and SH it stabilizes the entanglement also in real sector. Cognition would not be a passive formation of cognitive representations but would have causal power taming the randomness of quantum jumps making possible directed intentional will. Religions express this intuition in various ways: for

instance, the Finnish version of Genesis contains the sentence "First was the word". Also Finnish national epic gives magic power to the words: first comes the world and only after it what the word refers to.

7.4.3 Why deep learning neutral networks are so effective?

Deep learning means AI systems with large number of hierarchy levels: programs calling programs calling... is the first intuitive idea of AI outsider like me. These algorithms are learn from examples mimicking the formation of associations in brain. These programs can also rewrite themselves but all is based on given algorithm.

The surprising finding is that deep learning neural model work much better than one might expect on basis of mathematical arguments alone (see http://tinyurl.com/zvrmao7. This looks like a real mystery. The solution of the puzzle proposed by physicists is elegant. The physical world is much much simpler than mathematicians - wanting to be as general as possible - assume! Simplicity means among other things holography and hierarchical structures and deep learning relies on hierarchical structures. It would be amazing if AI and physics finally could meet each other (see the article of Lin and Tegmark at http://tinyurl.com/hz2jp8z and the remarks of Ben Goertzel at http://tinyurl.com/z8tcqht).

Holography and its strong form

The Universe is indeed very simple according to hololographic theories. For instance, in TGD not only holography but strong form of holography holds true. The quantum and classical data assignable to string world sheets and partonic 2-surfaces dictates the dynamics of 4-D space-time surface. This effective 2-dimensionality of dynamics means enormous simplification of the quantum physical world from what it could be. For instance, preferred extremals defining space-time surfaces satisfy infinite number of conditions stating vanishing of certain Noether charges.

This extreme simplicity is lost when the sheets of the many-sheeted are lumped together to obtain the space-time of general relativity and standard model and effective classical fields are sums over geometrizes classical fields associated with the sheets. In biological systems however the dynamics of many-sheetedness comes manifest and the actions of single sheet need not be masked: things get simple in this kind of situation.

Various fractal hierarchies

Holography need not the only reason for the simplicity. The possibly physical world of TGD has hierarchical fractal structure: length scale reductionism is replaced with fractality. Dynamics looks more or less similar in all zooms and this simplifies the situation of mimicker enormously. There are hierarchies of space-time sheets topologically condensed on larger space-time sheets, hierarchy of p-adic length scales defined by primes near powers of two (or more general small prime), hierarchy of Planck constants, self hierarchy. p-Adic length scale hierarchy allows extremely simple model for elementary particle masses: one might perhaps say that one does not model the mass of "real" particle but its cognitive representation about itself in terms of p-adic thermodynamics relying on conformal invariance. The hierarchy of Planck constants means fractal hierarchy of zoomups of system: dark matter phases assignable to quantum criticality would be crucial for the understanding of living systems.

These hierarchies also define hierarchies of measurement resolutions making possible abstraction, getting rid of details at the level of conscious experience and behavior. The hierarchical structure would be especially important for conscious mind. Self has subselves which it experiences as mental images and is mental image of higher level self. Goal hierarchies mean a lot of structural restrictions making it easier for artificial intelligence to mimick conscious systems.

p-Adic variant for the theory of computation?

In TGD Universe p-adic physics is physics of cognition and imagination and real physics also carries signatures about the presence of p-adic physics as p-adic fractality: this would explain the unexpected success of p-adic mass calculations [K74]. The outcome would be a fusion of real and

various p-adic number fields to form adeles. Each extension of rationals giving rise to a finitedimensional extension of p-adic numbers defines an adele, and there is hierarchy of adeles defining an evolutionary hierarchy. The better the simulation p-adic space-time sheet is for real space-time sheet, the larger the number of common algebraic points is. This intuitive idea leads to the notion of monadic geometry in which the discretization of the embedding space causal diamond is central for the definition of monadic space-time surfaces [L56]. They are smooth both in real and p-adic sense but involve discretization by algebraic points common to real and p-adic space-time surfaces for some algebraic extension of rationals inducing corresponding extension of p-adics.

How this could relate to computation? In the classical theory of computation recursive functions play a key role. Recursive functions are defined for integers. Can one define them for p-adic integers? At the first glance the only generalization of reals seems to be the allowance of p-adic integers containing infinite number of powers of p so that they are infinite as real integers. All functions defined for real integers having finite number of pinary digits make sense p-adically.

What is something competetely new that p-adic integers form a continuum in a well-defined sense and one can speak of differential calculus. Exact numerics is lost but p-adic continuity (the values f(x) and $f(x + kp^n)$) would be near to each other p-adically) and smoothness could make possible approximations and would allow to pose additional conditions on recursive functions for given prime p.

How could one map p-adic recursive function to its real counterpart? Does one just identify p-adic arguments and values as real integers or should one perform something more complex? The problem is that this correspondence is not continuous. Canonical identification for which the simplest form is $I: x_p = \sum_n x_n p^n \to \sum_n x_n p^{-n} = x_R$ would however relate p-adic to real arguments continuously [K87]. Note that the real counterpart is rational for finite p-adic integers and real number in the general case. Canonical identification has several variants typically mapping small enough real integers to p-adic integers as such and large enough integers in the same manner as I. In the following let us restrict the consideration to I.

Basically, one would have p-adic valued recursive function $f_p(x_p)$ with a p-adic valued argument x_p . One can assign to f_p a real valued function of real argument - call it f_R - by mapping the p-adic argument x_p to its real counterpart x_R and its value $y_p = f_p(x)$ to its real counterpart y_R : $f_R(x_R) = I(f(x_p) = y_R)$. I have called the functions in this manner p-adic fractals: fractality reflects directly to p-adic continuity. It should be made clear that canonical identification maps finite p-adic integers to real rationas and p-adic integers infinite as real integers to reals.

 f_R could be 2-valued. The reason is that p-adic numbers $x_p = 1$ and $x_p = (p-1)(p+p^2+..)$ are both mapped to real unit and one can have $f_p(1) \neq f_p((p-1)(p+p^2+..))$. This is a direct analog for 1 = .999... for decimal expansion. This generalizes to all p-adic integers finite as real integers: p-adic arguments $(x_0, x_1, ..., x_n, 0, 0, ...)$ and $(x_0, x_1, ..., x_n - 1, (p-1), (p-1), ...)$ are mapped to the same real argument x_R . Using finite pinary cutoff for x_p this ceases to be a problem.

Recursion plays a key role in the theory of computation and it would be nice if it would generalize in a non -trivial manner to the realm of p-adic integers (or general p-adic numbers).

1. From Wikipedia (see http://tinyurl.com/m9by2zn) one finds a nice article about primitive recursive functions. Primitive recursive functions are very simple. Constant function, successor function, projection function. From these more complex recursive functions are obtained by composition and primitive recursion. These functions are trivially recursive also in p-adic context and satisfy the conditions of p-adic continuity and smoothness. Composition respects these properties tool. I would guess that same holds also for primitive recursion.

It would seem that there is nothing new to be expected in the realm of natural numbers if one identifies p-adic integers as real integers as such. Situation changes if one uses canonical identification mapping p-adic integers to real numbers (for instance, $1 + 2 + 2^2 = 7 - -- > 1 + 1/2 + 1/4 = 7/4$ for 2-adic numbers). One could think of doing computations using p-adic integers and mapping the results to real numbers so that one could do computations with real numbers using p-adic integers and perhaps p-adic differential calculus so that computation using analytic computations would become possible instead of pure numerics. This could be very powerful tool.

2. One can consider also real valued recursive functions and functions having values in (not only) algebraic extensions of rationals. Exponent function is an interesting primitive recursive

function in real context: in p-adic context exp(x) exists p-adically if x has p-adic norm smaller than 1). exp(x + 1) does not exist as p-adic number unless one introduces extension of p-adic numbers containing e: this is necessary in physically interesting p-adic group theory. exp(x + kp) however exists as p-adic number. The composition of exp restricted to p-adic numbers with norm smaller than 1 with successor function does not exist. Extension of rationals containing e is needed if one wants successor axiom and exponential function.

3. The fact that most p-adic integers are infinite as real numbers might pose problems since one cannot perform infinite sums numerically. p-Adic continuity would of course allow approximations using finite number of pinary digits. The real counterparts of functions involved using canonical identification would be p-adic fractals: this is something highly non-trivial physically.

One could also code the calculations at higher level of abstraction by performing operations for functions rather than numbers. The finite arithmetics would be for the labels of functions using tables expression the rules for various operations for functions (such as multiplication). Build a function bases and form tables for various operations between them like multiplication table of algebra, computerize the operations using these tables and perform pinary cutoff at end. The rounding error would emerge only at this last step.

The unexpected success of deep learning is conjectured to reflect the simplicity of the physical world: only a small subset of recursive functions is needed in computer simulation. The real reason could be p-adic physics posing for each value of p very strong additional constraints on recursive functions coming from p-adic continuity and differentiability. p-Adic differential calculus would be possible for the p-adic completions of integers and could profoundly simplify the classical theory of computation.

Quantum states realize finite measurement resolution themselves

Conceptualization means hierarchies and one can say that TGD Universe performs this conceptualization for us! In fact, one can say that quantum state provides its own description. This implies that finite measurement resolution is not a property of description of quantum state but of quantum state itself! For instance, the larger the number of partonic 2-surfaces and string world sheets is, the better the "half-discretization" of 4-D space-time surface by these 2-surfaces is, and the more precise is the conscious experience of system about itself. For instance, magnetic flux tube networks with flux tubes accompanied by strings and with maximally entangled at the ends of nodes would give rise to a universal proprioception. The experience about 3-space would emerge from entanglement rather, not the 3-space as some colleagues fashionably argue.

Simplicity in cosmology

This extreme simplicity is most dramatic in cosmology. The microwave temperature is essentially constant. This cannot be due to the causal interactions but reflects something deeper. Inflationary scenarios are one attempt to explain this but have not led to a breakthrough. A more radical explanation is that macroscopic quantum coherence even in cosmological scales is possible at the space-time sheets of cosmic size scale with large value of Planck constant characterizing phases of ordinary matter behaving like dark matter. The key idea is generalization of point-like particle to 3-surface: particle and 3-space are one and same thing. Particles as 3-surfaces can have even cosmological size.

Deep learning neural nets could be seen as supporting the idea of computer consciousness is involved and therefore would be encouraging also from the point of view of IIT. In a well-defined sense these systems are intelligent, and one can even make them to mimic free will by using random generators. They are however not intentional and I think that this is the fatal failure. They are like some brain patients with a damaged frontal lobes. These persons are intelligent but cannot intend and realize their intentions in the time time scales needed in say everyday life.

Part II

QUANTUM BIOLOGY IN TGD UNIVERSE

Chapter 8

Quantum Mind, Magnetic Body, and Biological Body

8.1 Introduction

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. The basic new physics inspired ideas behind TGD inspired quantum biology have been discussed already in the first article but deserve to be listed.

The article is devoted to some applications of TGD inspired view about Quantum Mind to biology. Magnetic body carrying dark matter and forming an onion-like structure with layers characterized by large values of Planck constant is the key concept. 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 then. 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 the following I briefly summarize some applications to quantum biology. I am of course forced to leave details to the books about TGD inspired theory of consciousness and quantum biology at my homepage [K131, K25, K97, K60, K24, K71, K75, K120].

- 1. A vision about relationship between information processing and metabolism in TGD Universe is represented.
 - (a) The already existing ideas include the notion of time mirror mechanism as a ways to realized intentional action, memory recall, and remote metabolism by sending negative energy photons to geometric past where some system able to absorb them exists. The proposal is that the utilization of ATP is also possible in this way: this quantum credit card would make living matter extremely flexible since instantaneous reaction to changing circumstances would become possible. Many-sheeted space-time inspires the idea that the dropping of particles, in particular electrons and protons, to larger space-time sheets liberates metabolic energy. This mechanism would provide universal metabolic currencies and also ATP-ADP might be based on it.
 - (b) The new idea is that the presence of ATP at magnetic flux tube is a necessary prerequisite for negentropic entanglement between its ends. ATP could be seen as a molecule of consciousness in this picture and high energy phosphate bond would be replaced with

a state involving negentropic entanglement. There is also a connection with the model of living matter as quantum computer.

- (c) A possible modification of second law to take into account negentropic entanglement is discussed. The pessimistic modification states that genuine islands of negentropy can be generated rather than islands in which entropy is very small. The generation of negentropy is however always accompanied by compensating generation of entropy. A possible interpretation is that the eventual reduction of negentropic entanglement in state function reduction generates this entropy at ensemble level.
- 2. 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. These findings are briefly discussed in TGD framework by bringing in magnetic flux tubes as a new element.
- 3. Water is in key role in living matter and TGD inspired view about water and various anomalies related to the physics of water are also discussed.

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 [L31].

8.2 Quantum Mind And Magnetic Body

The notion of magnetic/field body (see Fig. http://tgdtheory.fi/appfigures/fluxquant.jpg or Fig. ?? in the appendix of this book) is probably the feature of TGD inspired theory of quantum biology which probably creates strongest irritation in standard model physicist. A ridicule as some kind of Mesmerism might be the probable reaction. The notion of magnetic/field body has however gradually gained more and more support and it is now an essential element of TGD based view about living matter. In the following I discuss the basic applications in the hope that the overall coherency of the picture might force some readers to take this notion seriously. The notion of magnetic body leads to a dramatic modification of the views about functions of brain and biological systems in general. I will talk mostly about magnetic body although it is clear that field body has also electric parts (electric flux quanta with cell membrane and various electrets populating living matter) as well as radiative parts realized in terms of "massless extremals" or topological light rays [K91] providing correlates for EEG and its fractal analogs.

8.2.1 Living Matter As Ordinary Matter Controlled By Dark Matter At Magnetic Bodies

The notions of many-sheeted space-time, topological field quantization, and magnetic body were in a key role in the model of living matter as a macroscopic quantum system. It was assumed that space-time sheets are not at thermal equilibrium and that the space-time sheets responsible for the macroscopic quantum coherence are at very low temperature. See the article "Biosystems as macroscopic quantum systems" [L1] and **Figs.** ??, ??, ??, and ?? in the appendix of this book.

1. Libet's findings and the model of memory based on time mirror hypothesis suggests that magnetic body is indeed needed. What is the real function of magnetic body? Is it just a sensory canvas? The previous considerations suggest that it is also the seat of geometric qualia, in particular the pitch of sound should be coded by it. It would be relatively easy to understand magnetic body as a relatively passive sensory perceiver defining sensory map. If one assumes that motor action is like time reversed sensory perception then sensory and motor pathways would be just sensory pathways proceeding in opposite time directions from receptors to the various layers of the magnetic body. Brain would perform the information processing.

Certainly there must exist a region in which the motor and sensory parts of the magnetic body interact. What comes in mind is that these space-time sheets (or actually pairs of space-time sheets) are parallel and generate wormhole contacts between them. This interaction would be assignable to the region of the magnetic body could receive positive energy signals from associative sensory areas and send negative energy signals to motor motor neurons at the ends of motor pathways wherefrom they would propagate to premotor cortex, supplementary motor cortex and to frontal lobes where the abstract plans about motor actions are generated.

- 2. The hierarchy of Planck constants and identification of dark matter as phases with nonstandard value of Planck constant makes it possible to give up the assumption about low temperatures at flux quanta. Dark matter becomes the key notion in the quantum controller of ordinary matter in living matter. The large value of Planck constant - integer multiple of standard value- scales up quantum lengths since typically they are proportional to \hbar and scales the quantum coherence lengths and times. This also scales the energy E = hfassociated with a photon with given frequency. This allows to understand the quantal effects of ELF em fields to vertebrate brain.
- 3. Large Planck constant means that quantum length scales such as Compton length are scaled up. This makes possible macroscopic quantum coherence and non-locality. Magnetic flux tubes are identified as carriers of dark matter with non-standard value of Planck constant.
- 4. The ideas about the role of magnetic flux quanta have evolved considerably. It is natural to assume that magnetic flux tubes carry macroscopic quantum phases of dark matter. The phase transitions changing Planck constant reduce or increase the length of the flux tube and could be responsible for the dramatic volume changes of cytoplasm. The reconnections of magnetic flux tubes make possible dynamics for the topology of the web formed by magnetic flux tubes. ATP-ADP process can be associated with this kind of reconnection process. The braiding of magnetic flux tubes makes possible topological quantum computations and DNA and lipid layers of cell membrane form an ideal hardware for topological quantum computer with braiding of flux tubes connecting lipid layers with DNA nucleotides defining the TQC programs. Braiding provides also a universal memory storage mechanism since liquid flow induces braiding of the particle in the flow. Lipid layers of cell membrane are indeed liquid crystals so that their flows update quantum computer programs coded by space-like braiding.
- 5. Living matter would be ordinary matter controlled by the dark manner at the "magnetic body" of the system and magnetic flux tubes and sheets act as carriers of dark matter. Phase transitions changing the value of Planck constant induce contractions or lengthenings of the flux tubes and would be key mechanism in the volume changing phase transitions in living matter. Reconnection process for the flux tubes is second mechanism and ATP-ADP mechanism would involve basically the reconnection which would in quantum computer inspired picture mean formation of a link to and address in memory. Braiding of flux tubes makes possible topological quantum computation. For details see the chapters

Macroscopic quantum coherence and metabolism as different sides of the same coin (see http://tinyurl.com/yd7j9f5j) [K68].

DNA as topological quantum computer (see http://tinyurl.com/ybyscdpt) [K6].

Dark Matter Hierarchy and Hierarchy of EEGs (see http://tinyurl.com/y9y87z84) [K48].

TGD Based View about Classical Fields in Relation to Consciousness Theory and Quantum Biology (see http://tinyurl.com/y9exp84r) [K128].

Quantum model for bio-superconductivity:part I (see http://tinyurl.com/yahrlysf) [K100]. Quantum model for bio-superconductivity:part II (see http://tinyurl.com/y7fbb4hm) [K101]. Quantum model for nervepulse (see http://tinyurl.com/y8e5oqkm) [K103].

8.2.2 Magnetic Body As Intentional Agent And Experiencer

In TGD Universe brain would be basically a builder of symbolic representations assigning a meaning to the sensory input by decomposing sensory field to objects and making possible effective motor control by magnetic body containing dark matter. A concrete model for how magnetic controls biological body and receives information from it is discussed in the model for the nerve pulse [K103] and for the hierarchy of EEGs [K48, K105].

Also magnetic body could have sensory qualia, which should be in a well-defined sense more refined than ordinary sensory qualia [K59]. The quantum number increments associated with cyclotron phase transitions of dark ion cyclotron condensates at magnetic body could relate to the cognitive and possibly also emotional content of sensory input and would indeed have interpretation as higher level sensory qualia. On the other hand, the positive/negative emotional coloring itself might be the core of what it is to be emotion and most naturally relates to the sign of negentropy increment in quantum jump so that it would not be a quale in the sense that visual colors are.

Right brain sings – left brain talks metaphor could characterize this emotional-cognitive (holistic-reductionistic) distinction for higher level qualia and would correspond to coding of sensory input from brain by frequency patterns *resp.* temporal patterns (analogs of phonemes). Fourier analysis indeed transforms local data into holistic data.

These qualia could be seen as somatosensory qualia at the level of magnetic body. One must be however cautious with interpretations. It is not all obvious whether the qualia should be assigned with body alone or magnetic body alone or both. Out of body experiences and various illusions such as train illusion and the disgusting sensation about falling when one is near the edge of cliff could be virtual world experiences resulting from the relative motion of the magnetic body with respect to the biological body: the sensory sensation would correspond to to the interference effects for dark photon radiation between the biological body and magnetic body [K127].

TGD framework fundamental qualia are associated with sensory receptors although also neuronal qualia are possible. The new view about time allows to overcome the arguments suggesting that qualia must be solely at the level of brain (say the pain in phantom limb).

Remote mental interactions between magnetic body and biological body are a key element of this picture. Remote mental interactions in the usual sense of the world would occur between magnetic body and some other, not necessary biological, body. This would include receival of sensory input from and motor control of other than own body. Also inanimate matter (no negentropic entanglement) possesses magnetic bodies (so that also psychokinesis could be based on the same mechanism). Magnetic body for which dissipation is much smaller than for ordinary matter (proportional to $1/\hbar$), could continue its conscious existence after biological death and find another biological body and use it as a tool of sensory perception and intentional action.

8.2.3 Time Mirror Mechanism Can Be Seen As The Basic Mechanism Of Memory, Intentional Action, And Metabolism

It means sending negative energy signal propagating backwards in time and ZEO gives precise meaning for this notion.

- 1. Memory recall in the case of symbolic memories would correspond to sending of negative energy signal to geometric past. The signal would be reflected as positive energy signal. An alternative possibility is that time-like entanglement is generated. This mechanism would make it un-necessary to store memories again and again. The proposed model for the recent finding that memory code with six bits might make sense suggests that metabolism is necessarily involved. The negative energy quantum absorbed in geometric past transforms ATP to ADP and deletes the conscious memory item but creates it again in the geometric now. This would conform with no-cloning theorem.
- 2. Sending of negative energy signals to a system serving as energy storage to generate metabolic energy as a recoil makes possible an extremely flexible quantum credit card in living matter. This kind of flexibility is extremely useful in circumstances requiring very rapid reactions.
- 3. Motor actions could be regarded as realizations of intentions using negative energy signals propagating to the direction of geometric past. This hypothesis would explain the strange finding of Libet that conscious decision in volitional action seems to occur later than the neural activity initiating the motor action. One could argue that the free will aspect of motor actions does not conform with the interpretation as sensory perception in reversed direction of time. On the other hand, also percepts are selected -say in binocular rivalry [J34]. Only single alternative percept need to be realized in a given branch of the multiverse. This makes possible metabolic economy: for instance, the synchronous firing at kHz frequency serving as a correlate for the conscious percept requires a lot of energy since dark photons at kHz

frequency have energies above thermal threshold. Similar selection of percepts could occur also at the level of sensory receptors but quantum statistical determinism would guarantee reliable perception. The passivity of sensory perception and activity of motor activity would reflect the breaking of the arrow of time if this interpretation is correct.

8.2.4 Biosystems 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 Feynman diagram like structure consisting of lines representing matter (say charged particles) and bosons (say photons). The matter lines are replaced by spacetime 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 the Feynman 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 Feynman 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 (see Fig. http://tgdtheory.fi/appfigures/timemirror.jpg or Fig. ?? in the appendix of this book) is a key element of intentional action. The notion of fourwave 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 is full of this kid 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.

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 manysheeted 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.

8.2.5 High T_c Superconductivity In Living Matter

The TGD inspired model for high T_c super-conductivity as quantum critical phenomenon is developed. The relies on the notions of quantum criticality, dynamical quantized Planck constant requiring a generalization of the 8-D embedding space to a book like structure, and many-sheeted space-time. In particular, the notion of magnetic flux tube as a carrier of supra current of central concept.

The model of super-conductivity

The model for generalized EEG relates very closely to the general model of high T_c superconductivity. This motivates a separate discussion of the vision about bio-super-conductivity in TGD Universe.

1. General mechanisms of bio-superconductivity

The many-sheeted space-time concept provides a very general mechanism of superconductivity based on the "dropping" of charged particles from atomic space-time sheets to larger space-time sheets. The first guess was that larger space-time sheets are very dry, cool and silent so that the necessary conditions for the formation of high T_c macroscopic quantum phases are met.

The possibility of large \hbar quantum coherent phases makes however the assumption about thermal isolation between space-time sheets un-necessary. At larger space-time sheet the interactions of the charged particles with classical em fields generated by various wormhole contacts feeding gauge fluxes to and from the space-time sheet in question give rise to the necessary gap energy. The simplest model for Cooper pair is space-time sheet containing charged particles having attractive Coulombic interaction with the quarks and antiquarks associated with the throats of the wormhole contacts.

Wormhole contacts can be interpreted as Higgs type fields and photon massivation could be understood in terms of a coherent state of charged wormhole contacts. The coherent states of charged wormhole contacts and of Cooper pairs do not imply non-conservation of energy, charge, and fermion number in zero energy ontology.

A crucial element is quantum criticality predicting a new kind of superconductivity explaining the strange features of high T_c super-conductivity. There are two kinds of Cooper pairs, exotic Cooper pairs and counterparts of ordinary BCS type Cooper pairs. Both correspond to a large value of Planck constant. Exotic Cooper pairs are quantum critical meaning that they can decay to ordinary electrons. Below temperature $T_{c_1} > T_c$ only exotic Cooper pairs with spin are present and their finite lifetime implies that super-conductivity is broken to ordinary conductivity satisfying scaling laws characteristic for criticality. At T_c spinless BCS type Cooper pairs become stable and exotic Cooper pairs can decay to them and vice versa. An open question is whether the BCS type Cooper pairs can be present also in the interior of cell.

These two superconducting phases compete in certain narrow interval around critical temperature for which body temperature of endotherms is a good candidate in the case of living matter. Also high T_c superfluidity of bosonic atoms dropped to space-time sheets of electronic Cooper pairs becomes possible besides ionic super conductivity. Even dark neutrino superconductivity can be considered below the weak length scale of scaled down weak bosons.

Magnetic magnetic flux tubes and sheets are especially interesting candidates for supra current carries. In this case the Cooper pairs must have spin one and this is indeed possible for exotic Cooper pairs. The fact that the critical magnetic fields can be very weak or large values of \hbar is in accordance with the idea that various almost topological quantum numbers characterizing induced magnetic fields provide a storage mechanism of bio-information.

This mechanism is extremely general and in principle works for electrons, protons, ions, charged molecules and even exotic neutrinos and an entire zoo of high T_c bio-superconductors, super-fluids and Bose-Einstein condensates is predicted. Of course, there are restrictions due to

the thermal stability it room temperature and it seems that only electron, neutrino, and proton Cooper pairs are possible at room temperature besides Bose-Einstein condensates of all bosonic ions and their exotic counterparts resulting when some nuclear color bonds become charged.

2. Hierarchies of preferred p-adic length scales and values of Planck constant

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.

The hypothesis that Mersenne primes $M_k = 2^k - 1$, $k \in \{89, 107, 127\}$, and Gaussian Mersennes $M_{G,k} = (1+i)k - 1$, $k \in \{113, 151, 157, 163, 167, 239, 241..\}$ (the number theoretical miracle is that all the four p-adic length scales sith $k \in \{151, 157, 163, 167\}$ are in the biologically highly interesting range 10 nm-2.5 μ m) define scaled up copies of electro-weak and QCD type physics with ordinary value of \hbar and that these physics are induced by dark variants of corresponding lower level physics leads to a prediction for the preferred values of $r = 2^{k_d}$, $k_d = k_i - k_j$, and the resulting picture finds support from the ensuing models for biological evolution and for EEG [?] This hypothesis - to be referred to as Mersenne hypothesis - replaces the earlier rather ad hoc proposal $r = \hbar/\hbar_0 = 2^{11k}$ for the preferred values of Planck constant.

The role of Josephson currents

The general vision is that Josephson currents of various ions generate Josephson photons having dual interpretations as bio-photons and EEG photons. Josephson photons can in principle regenerate the quale in the neurons of the sensory pathway. In the case of motor pathways the function would be different and the transfer of metabolic energy by quantum credit card mechanism using phase conjugate photons is suggested by the observation that basic metabolic quanta 2 eV *resp.* 4 eV are associated with smooth muscle cells *resp.* skeletal muscle cells.

As already found in the previous section, the energies of Josephson photons associated with the biologically important ions are in general in visible or UV range except when resting potential has the value of -40 mV which it has for photoreceptors. In this case also IR photons are present. Also the turning point value of membrane potential is +40 mV so that one expects the emission of IR photons.

Josephson photons could be used to communicate the qualia to the magnetic body.

- 1. If Josephson currents are present during the entire action potential, the entire range of Josephson photons down to frequencies of order 2 kHz range is emitted for the standard value of \hbar . The reason is that lower frequencies corresponds to cycles longer than the duration of the action potential. The continuum of Josephson frequencies during nerve pulse makes it possible to induce cyclotron transitions at the magnetic body of neuron or large structure. This would make possible to communicate information about spatial and temporal behavior of the nerve pulse pattern to the magnetic body and build by quantum entanglement a sensory map.
- 2. The frequencies below 2 kHz could be communicated as nerve pulse patterns. When the pulse rate is above f = 28.57 Hz the sequence of pulses is experienced as a continuous sound with pitch f. f defines the minimum frequency for which nerve pulses could represent the pitch and there remains a 9 Hz long range to be covered by some other communication method.
- 3. The cyclotron frequencies of quarks and possibly also of electron would make possible a selective reception of the frequencies emitted during nerve pulse. Same applies also to the Josephson frequencies of hair cell (, which does not fire). If the value of Planck constant is large this makes possible to communicate the entire range of audible frequencies to the magnetic body. Frequency would be coded by the magnetic field strength of the flux tube. Two options are available corresponding to the standard ground state for which Z^0 field is

fermion	$f_c(e)/MHz$	$f_c(u)/MHz$	$f_c(d)/MHz$
standard	.564	.094	.019
nearly vacuum extremal	8.996	2.275	.947

Table 8.1: Cyclotron frequencies of quarks and electron in magnetic field $B_{end} = .2$ Gauss for standard vacuum with very small Z^0 field and nearly vacuum extremal.

very weak and to almost vacuum extremals. For the first option one as ordinary cyclotron frequencies. The cyclotron frequency scales for them differ by a factor

$$r(q) = \frac{Q_{eff}(q)}{Q_{em}(q)} = \frac{\epsilon(q)}{2pQ_{em}(q)} + 1 \ per, \ \epsilon(u) = -1 \ , \epsilon(d) = 1$$

from the standard one. For p = .0295 one obtains (r(u), r(d), r(e) = (24.42, 49.85, 15.95). The cyclotron frequencies for quarks and electron with masses m(u)=2 MeV, m(d)=5 MeV, and m(e)=.5 MeV are given **Table 8.1** for the two options. If one assumes that B_{end} defines the upper bound for field strength then he standard option would require both d quark and electron. Gor dquark with kHz CD the upper bound for cyclotron frequencies would be 20 kHz which corresponds to the upper limit of audible frequencies.

4. Besides cyclotron frequencies also the harmonics of the fundamental frequencies assignable to quark and electron CDs could be used and in case of musical sounds this looks a highly attractive option. In this case it is now however possible to select single harmonics as in the case of cyclotron transitions so that only the rate of nerve pulses can communicate single frequency. Lorentz transform sub-CD scales up the frequency scale from the secondary p-adic time scale coming as octave of 10 Hz frequency. Also the scaling of \hbar scales this frequency scale.

4. What are the roles of Josephson and cyclotron photons?

The dual interpretation of Josephson radiation in terms of bio-photons and EEG photons seems to be very natural and also the role of Josephson radiation seems now relatively clear. The role of cyclotron radiation and its interaction with Josephson radiation are not so well understood.

- 1. At least cell membrane defines a Josephson junction (actually a collection of them idealizable as single junctions). DNA double strand could define a series of Josephson junctions possibly assignable with hydrogen bonds. This however requires that the strands carry some non-standard charge densities and currents- I do not know whether this possibility is excluded experimentally. Quarks and antiquarks assignable to the nucleotide and its conjugate have opposite charges at the two sheets of the wormhole flux tube connective nucleotide to a lipid. Hence one could consider the possibility that a connection generated between them by reconnection mechanism could create Josephson junction.
- 2. The model for the photoreceptors leads to the identification of bio-photons as Josephson radiation and suggests that Josephson radiation propagates along flux tubes assignable to the cell membranes along sensory pathways up to sensory cortex and from there to motor cortex and back to the muscles and regenerates induced neuronal sensory experiences.
- 3. Josephson radiation could be used quite generally to communicate sensory data to/along the magnetic body: this would occur in the case of cell membrane magnetic body at least. The different resting voltages for various kinds of cells would select specific Josephson frequencies as communication channels.
- 4. If motor action indeed involves negative energy signals backwards in geometric time as Libet's findings suggest, then motor action would be very much like sensory perception in time reversed direction. The membrane resting potentials are different for various types of neurons

and cells so that one could speak about pathways characterized by Josephson frequencies determined by the membrane potential. Each ion would have its own Josephson frequency characteristizing the sensory or motor pathway.

The basic questions concern the function of cyclotron radiation and whether Josephson radiation induces resonantly cyclotron radiation or vice versa.

- 1. Cyclotron radiation would be naturally associated with the flux sheets and flux tubes. The simplest hypothesis is that at least the magnetic field $B_{end} = .2$ Gauss can be assigned with the some magnetic flux quanta at least. The model for hearing suggests that B_{end} is in this case quantized so that cyclotron frequencies provide a magnetic representation for audible frequencies. Flux quantization does not pose any conditions on the magnetic field strength if the above discussed general flux quantization condition involving charged currents at the boundary of the flux quantum are assumed. If these currents are not present, $1/\hbar$ scaling of B_{end} for flux tubes follows.
- 2. The assumption that cyclotron radiation is associated with the motor control via genome is not consistent with the vision that motor action is time reversed sensory perception. It would also create the unpleasant question about information processing of the magnetic body performed between the receival of sensory data and motor action.
- 3. The notion of magnetic sensory canvas suggests a different picture. Josephson radiation induces resonant cyclotron transitions at the magnetic body and induces entanglement of the mental images in brain with the points of the magnetic body and in this manner creates sensory maps giving a third person perspective about the biological body. There would be two kind of sensory maps. Those assignable to the external world and those assignable to the body itself. The Josephson radiation would propagate along the flux tubes to the magnetic body.
- 4. There could be also flux tube connections to the outer magnetosphere of Earth. It would seem that the reconnections could be flux tubes traversing through inner magnetosphere to poles and from there to the outer magnetosphere. These could correspond to rather low cyclotron frequencies. Especially interesting structure in this respect is the magnetic flux sheet at the Equator.

8.2.6 Possible Roles Of The Magnetic Body In Living Matter

An attractive working hypothesis is that dark matter and negentropic entanglement can be assigned to the magnetic bodies. For instance, the dark elementary particles at the ends of the magnetic flux tubes connecting (say) biomolecules could be entangled negentropically. Negentropic entanglement, which is not identifiable as ordinary bound state entanglement, can be applied to explain the stability of high energy phosphate bond in ADP and ATP and of DNA polymers, which are highly charged and thus expected to be unstable [?]. This also allows to interpret metabolic energy transfer as a transfer of negentropic entanglement at the deeper level.

The anatomy of magnetic body

Consider first the anatomy of the magnetic body.

1. Magnetic body has a fractal onion like structure with decreasing magnetic field strengths and the highest layers can have astrophysical sizes. Cyclotron wave length gives an estimate for the size of particular layer of magnetic body. B = .2 Gauss is the field strength associated with a particular layer of the magnetic body assignable to vertebrates and EEG. This value is not the same as the nominal value of the Earth's magnetic field equal to.5 Gauss and follows from the TGD based explanation of the quantal effects of ELF em fields on vertebrate brain known for decades [J23]. It is quite possible that the flux quanta of the magnetic body correspond to those of wormhole magnetic field and thus consist of two parallel flux quanta which have opposite time orientation. This is true for flux tubes assigned to DNA in the model of DNA as a topological quantum computer [K6, K138].

- 2. The layers of the magnetic body are characterized by the values of Planck constant and the matter at the flux quanta can be interpreted as macroscopically quantum coherent dark matter. This picture makes sense only if one accepts the generalization of the notion of embedding space [K47].
- 3. In the case of wormhole magnetic fields it is natural to assign a definite temporal duration to the flux quanta and the time scales defined by EEG frequencies are natural. Encouragingly, the inherent time scale.1 seconds assignable to electron as a duration of zero energy space-time sheet in zero energy ontology having positive and negative energy electron at its ends would correspond to 10 Hz cyclotron frequency for ordinary value of Planck constant. For larger values of Planck constants the time scale scales as \hbar . Quite generally, a connection between p-adic time scales of EEG and those of electron and lightest quarks is highly suggestive since light quarks play key role in the model of DNA as topological quantum computer.
- 4. TGD predicts also a fractal hierarchy of scaled variants of electro-weak and color physics so that ZXG, QXG, and GXG corresponding to Z^0 boson, W boson, and gluons appearing effectively as massless dark particles below some biologically relevant length scale suggest themselves. In this phase quarks and gluons are unconfined and electroweak symmetries are unbroken so that gluons, weak bosons, quarks and even neutrinos might be relevant to the understanding of living matter. In particular, long ranged entanglement in charge and color degrees of freedom becomes possible. For instance, TGD based model of atomic nucleus as nuclear string suggests that biologically important fermionic could be actually chemically equivalent bosons and form cyclotron Bose-Einstein condensates.

This picture would mean that dark matter -usually believed to interact extremely weakly with the ordinary matter- would become a key player in biology. The failure to observe dark matter would be the completely wrong view about its nature. In TGD framework dark matter would make itself visible both via classical em fields and via the phase transitions transforming dark photons to ordinary ones. For instance, bunches of EEG photons and bio-photons could be interpreted as decay products dark photons [K48].

What magnetic body looks like?

What magnetic body looks like has been a question that I have intentionally avoided as a question making sense only when more general questions have been answered. This question seems how unavoidable now. Some of the related questions are following. The magnetic flux lines along various parts of magnetic body must close: how does this happen? Magnetic body must have parts of size at least that defined by EEG wavelengths: how do these parts form closed structures? How the magnetic bodies assignable to biomolecules relate to the Earth sized parts of the magnetic body? How the personal magnetic body relates to the magnetic body of Earth?

- 1. The vision about genome as the brain of cell would suggest that active and passive DNA strands are analogous to motor and sensor areas of brain. This would suggests that sensory data should be communicated from the cell membrane along the passive DNA strand. The simplest hypotesis is that there is a pair of flux sheet going through the DNA strands. The flux sheet through the passive strand would be specialized to communicate sensory information to the magnetic body and the flux sheet through the active strand would generate motor action as DNA expression with transcription of RNA defining only one particular aspect of gene expression. Topological quantum computation assignable to introns and also electromagnetic gene expression would be possible.
- 2. The model for sensory receptor in terms of Josephson radiation suggests however that flux tubes assignable to axonal membranes carry Josephson radiation. Maybe the flux tube structures assigned to DNA define the magnetic analog of motor areas and flux tubes assigned with the axons that of sensory areas.
- 3. A complex structure of flux tubes and sheets is suggestive at the cellular level. The flux tubes assignable to the axons would be parallel to the sensory and motor pathways. Also microtubules would be accompanied by magnetic flux tubes. DNA as topological quantum

computer model assumes and the proposed model of sensory perception and cell membrane level suggests transversal flux tubes between lipids and nucleotides. The general vision about DNA as brain of cell suggest flux sheets through DNA strands.

During sensory perception of cell and nerve pulse the wormhole flux tube connecting the passive DNA strand of the first cell to the inner lipid layer would recombine with the flux tube connecting outer lipid layer to some other cell to form single flux tube connecting two cells. In the case of sensory organs these other cells would be naturally other sensory receptors. This would give rise to a dynamical network of flux tubes and sheets and axonal sequences of genomes would be like lines of text at the page of book. This structure could have a fractal generalization and would give rise to an integration of genome to super-genome at the level of organelles, organs and organism and even hypergenome at the level of population. This would make possible a coherent gene expression.

4. This vision gives some idea about magnetic body in the scale of cell but does not say much about it in longer scales. The CDs of electrons and quarks could provide insights about the size scale for the most relevant parts of the magnetic body. Certainly the flux tubes should close even when they have the length scale defined by the size of Earth.

Additional ideas about the structure follow follow if one assumes that magnetic body acts a sensory canvas and that motor action can be regarded as time reversed sensory perception.

- 1. If the external world is represented at part of the magnetic body which is stationary, the rotation of head or body would not affect the sensory representation. This part of the magnetic body would be obviously analogous to the outer magnetosphere, which does not rotate with Earth.
- 2. The part of the magnetic body at which the sensory data about body (posture, head orientations and position, positions of body parts) is represented, should be fixed to body and change its orientation with it so that bodily motions would be represented as motions of the magnetic, which would be therefore analogous to the inner magnetosphere of rotating Earth.
- 3. The outer part of the personal magnetic body is fixed to the inner magnetosphere, which defines the reference frame. The outer part might be even identifiable as the inner magnetosphere receiving sensory input from the biosphere. This magnetic super-organism would have various life forms as its sensory receptors and muscle neurons. This would give quantitative ideas about cyclotron frequencies involved. The wavelengths assignable to the frequencies above 10 Hz would correspond to the size scale of the inner magnetosphere and those below to the outer magnetosphere. During sleep only the EEG communications with outer magnetic body would remain intact.
- 4. Flux quantization for large value of \hbar poses an additional constraint on the model.
 - (a) If Josephson photons are transformed to a bunch of ordinary small \hbar photons magnetic flux tubes can correspond to the ordinary value of Planck constant. If one assumes the quantization of the magnetic flux in the form

$$\int B dA = n\hbar$$

used in super-conductivity, the radius of the flux tube must increase as $\sqrt{\hbar}$ and if the Josephson frequency is reduced to the sound frequency, the value of \hbar codes for the sound frequency. This leads to problems since the transversal thickness of flux tubes becomes too large. This does not however mean that the condition might not make sense: for instance, in the case of flux sheets going through DNA strands the condition might apply.

(b) The quantization of magnetic flux could be replaced by a more general condition

$$\oint (p - ZeA)dl = n\hbar \quad , \tag{8.2.1}$$

where p represents momentum of particle of super-conducting phase at the boundary of flux tube. In this case also n = 0 is possible and poses no conditions on the thickness of the flux tube as a function of \hbar . This option looks reasonable since the charged particles at the boundary of flux tube would act as sources of the magnetic field.

(c) Together with the Maxwell's equation giving B = ZeNv in the case that there is only one kind of charge carrier this gives the expression

$$N = \frac{2m}{RZ^2e^2} \tag{8.2.2}$$

for the surface density N of charge carrier with charge Z. R denotes the radius of the flux tube. If several charge carriers are present one has $B = \sum_k N_k Z_k ev_k$, and the condition generalizes to

$$N_i = \frac{2m_i v_i}{RZ_i \sum_k Z_k v_k e^2}$$

$$(8.2.3)$$

It seems that this condition is the most realistic one for the large \hbar flux sheets at which Josephson radiation induces cyclotron transitions.

Some functions of the magnetic body

The list of possible functions of the magnetic body is already now rather impressive.

- 1. Magnetic body controls biological body and receives sensory data from it. Together with zero energy ontology and new view about time explains Libet's strange findings about time lapses of consciousness [J42] in terms of time taken for the sensory signals from biological body to propagate to the appropriate layer of the magnetic body [K48]. EEG, or actually fractal hierarchy of EXGs assignable to various body parts makes possible communications to and control by the various layers of the magnetic body. WXG could induce charge density gradients by the exchange of W boson. Also the gluonic counterparts of EXG: s -QXG- are possible.
- 2. The flux sheets of the magnetic body traverse through DNA strands. The hierarchy of Planck constants and quantization of magnetic flux predicts that the flux sheets can have arbitrarily large width [K61]. This leads to the idea that there is hierarchy of genomes corresponding to ordinary genome, supergenome consisting of genomes of several cell nuclei arranged along flux sheet like lines of text, and hypergenomes involving genomes of several organisms arranged in a similar manner. The prediction is coherent gene expression at the level of organ, and even of population.

For instance, one could see the observed correlations between EEGs of two improvising musicians [J44], the findings of Germine [J85] and also those of Persinger and colleagues about macro-entanglement [J95] as an experimental support for both macroscopic entanglement between brain and for the crucial role of magnetic body as a space-time correlate for this entanglement. In this picture the great leaps in evolution, in particular, the emergence of EEG, could be seen as the emergence of a new larger layer of magnetic body characterized by a larger value of Planck constant. For instance, this would allow to understand why the quantal effects of ELF em fields [J23] requiring so large a value of Planck constant that cyclotron energies are above thermal energy at body temperature are observed for vertebrates only.

3. Magnetic body makes possible information processing in a way highly analogous to topological quantum computation [K6]. The model of DNA as topological quantum computer [K6] assumes that flux tubes of wormhole magnetic field connect DNA nucleotides with the lipids of the lipid layer of nuclear or cell membrane. The flux tubes would continue through the membrane and split during topological quantum computation. The time-like braiding of flux tubes makes possible topological quantum computation via time-like braiding and the induced space-like braiding makes possible the representation of memories. The model allows general vision about the deeper meaning of the structure of cell and makes testable predictions about DNA. A good metaphor is dancers with feet connected to the walls of the dancing hall by threads. The dance representing quantum computation is coded to the braiding of the threads.

One prediction is the coloring of braid strands realized by an association of quark or antiquark to nucleotide so that scaled up dark copy of QCD in cellular length scale would be involved. Color and spin of quarks and antiquarks would thus correspond to the quantum numbers assignable to braid ends. Color isospin could replace ordinary spin as a representation of qubit and quarks would naturally give rise to qutrit, with third quark would have interpretation as unspecified truth value. Fractionization of these quantum numbers takes place which increases the number of degrees of freedom.

This prediction would relate closely to the discovery of topologist Barbara Shipman [A8] that the model for the honeybee dance suggests that quarks are in some manner involved with cognition -something totally unimaginable unless one accepts the possibility of fractal hierarchies of electroweak and hadronic physics. Also microtubules associated with axons connected to a space-time sheet outside axonal membrane via lipids could be involved with topological quantum computation and actually define an analog of a higher level programming language.

4. The strange findings about the behavior of cell membrane are summarized in [I82] and discussed in TGD framework in [K103]. Mention only the finding that metabolic deprivation does not lead to the death of cell, the discovery that ionic currents through the cell membrane are quantal, and that these currents are essentially similar than those through an artificial membrane, suggest that the ionic currents are dark ionic Josephson currents along magnetic flux tubes. A high percent of biological ions would be dark and ionic channels and pumps would be responsible only for the control of the flow of ordinary ions through cell membrane.

A further important finding is that the water in the cell interior in gel phase is ordered and nearer to ice that liquid [I82]. This explains nicely the stability of DNA and various biopolymers as being due to the fact that depolymetrization by hydration is not possible in this phase. One could envisage the resting state of cell as a cellular winter during which proteins are folded or frozen to unfolded configurations by strong hydrogen bonds. External perturbation feeds energy to the system and induces periods during which the ice is frozen and proteins wake up and begin to unfold or fold and form aggretates as a response to the perturbation and return to the ground state after the energy of the signal is dissipated.

5. These findings together with the discovery that also nerve pulse seems to involve only low dissipation lead to a model of nerve pulse in which dark ionic currents automatically return back as Josephson currents without any need for pumping. This does not exclude the possibility that ionic channels might be involved with the generation of nerve pulse. In TGD inspired model [K103] nerve pulse would result as a perturbation of $f \simeq 1$ kHz frequency soliton sequence mathematically equivalent to a situation in which a sequence of gravitational penduli rotates with constant phase difference between neighbors except for one pendulum which oscillates and oscillation moves along the sequence with the same velocity as the kHz wave. The oscillation would be induced by a "kick" for which one can imagine several mechanisms. Nerve pulse would be like dissonance in background harmony. This view conforms with the general vision that any equilibium in living matter is homeostasis rather than analog of equilibrium in mechanical system.

The model explains some features of nerve pulse not explained by Hodkin-Huxley model. These include the mechanical changes associated with axon during nerve pulse, the outwards force generated by nerve pulse with a correct prediction for its order of magnitude, the adiabatic character of nerve pulse, and the small rise of temperature of membrane during pulse followed by a reduction slightly below the original temperature.

The model predicts that the time taken to travel along any axon is a multiple of time dictated by the resting potential so that synchronization is an automatic prediction and would have nothing to do with transmitters. Not only kHz waves but also a fractal hierarchy of EEG (and EXG) waves are induced as Josephson radiation by voltage waves along axons and microtubules and by standing waves assignable to neuronal (cell) soma. The value of Planck constant involved with flux tubes determines the frequency scale of EXG so that a fractal hierarchy results.

The model forces to challenge the existing interpretation of nerve pulse patterns and the function of neural transmitters. Neural transmitters need not represent actual/only) signal but could be more analogous to links in quantum web. The transmitter would code the address of the receiver, which could be a gene inside neuronal nucleus. Nerve pulses would build a connection line between sender and receiver of nerve pulse along which actual signals would propagate. Also quantum entanglement between receiver and sender can be considered.

6. Acupuncture points, meridians, and Chi are key notions of Eastern medicine and find a natural identification in terms of magnetic body lacking from the western medicine. Also a connection with well established notions of DC currents and potentials discovered by Becker and with TGD based view about universal metabolic currencies as differences of zero point energies for pairs of space-time sheets with different p-adic length scale emerges [K68]. The spectrum for increments of zero point kinetic energies represents lines which cannot be explained in terms of molecule physics and the empirical evidence for them is discussed in [K17]

Chi would correspond to these fundamental metabolic energy quanta to which ordinary chemically stored metabolic energy would be transformed. The identification nearest in spirit to the original intuition would be in terms of negentropic entanglement. Meridians would most naturally correspond to flux tubes with large \hbar along which dark supra currents flow without dissipation and transfer the metabolic energy between distant cells. Acupuncture points would correspond to points between which metabolic energy is transferred and their high conductivity and semiconductor like behavior would conform with the interpretation in terms of metabolic energy storages.

The energy gained in the potential difference between the points would help to kick the charge carrier to a smaller space-time sheet. It is possible that the main contribution to the of charge at magnetic flux tube is magnetic energy and slightly below the metabolic energy quantum and that the voltage difference gives only the lacking small energy increment making the transfer possible. Also direct kicking of charge carriers to smaller space-time sheets by photons is possible and the observed action spectrum for IR and red photons corresponds to the predicted increments of zero point kinetic energies.

- 7. The notion of magnetic body implicates the notion of magnetic motor actions. Magnetic flux tubes and their motor actions could play key role in bio-catalysis and explain the magic ability of biomolecules to find each other. The model of DNA as topological quantum computer [K6] suggest that not only DNA and its conjugate but also some amino-acid sequences acting as catalysts could be connected to DNA and other amino-acids sequences or more general biomolecules by flux tubes acting as colored braid strands. The shortening of the flux tubes in a phase transition reducing the value of Planck constant would make possible extremely selective mechanisms of catalysis allowing precisely defined locations of reacting molecules to attach to each other. With recently discovered mechanism for programming sequences of biochemical reactions (based on idea that each step in the reaction sequence means key allowing to open the door to the room containing the next key) [I90] this would make possible to understand the miraculous looking feats of bio-catalysis. Second key mechanism would be the re-connection of the magnetic flux tubes changing the topology of the Indra's net formed by magnetic flux tubes having biomolecules at their nodes.
- 8. Water memory is one of the highly disputed notions and motivated by the claimed effects of homeopathy. Water memory for which the work of the group led by HIV Nobelist L. Montagnier [I60] gives support would be naturally based on the coding of the biologically relevant properties of molecules to the cyclotron frequencies of its magnetic body. Water memory could rely on the copies of this magnetic body.

Quite surprisingly, the finding of the group suggest also that genetic code might have hitherto unknown realization. TGD indeed predicts several realizations, for instance those based on electromagnetic field patterns [K61]. The model of watermemory [K62] in turn led to a theoretical surprise [K138]. One could understand DNA, RNA, tRNA, and amino-acids in terms of states of dark nucleons constructed from three quarks and that vertebrate genetic code follows as a prediction in the sense that the numbers of counterparts of DNA codons coding for given amino-adic are predicted correctly [L3]. Prebiotic evolution as a process leading to a chemical realization of fundamental codes and counterparts of biomolecules existing already at the level of elementary particle physics together with the reduction of metabolic currencies to increments of zero point energies would solve two egg or hen problems of theoretical biology.

There is no reason to assume that dark genes would not be still there and in close interaction with ordinary genes and in principle they could make possible controlled evolution analogous to industrial R&D process based on the construction of new genetic variants at the virtual world level of dark genes and the transcriptions to ordinary genes so that the new options could be tested under real life situations.

9. Although not directly related to the notion of magnetic body, the ability to construct "stories", temporally scaled down or possible also scaled up representations about the dynamical processes of external world, deserves to be mentioned. This ability might be actually one of the key aspects of intelligence [K6]. There is direct empirical evidence for this activity in hippocampus [J113]. The phase transitions reducing or increasing the value of Planck constant would indeed allow to achieve this by scaling the time duration of the zero energy space-time sheets providing cognitive representations.

How genetic code could be represented in terms of frequencies? The TGD based model of music harmony [L32] [K102] (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.

Dark water and water memory: genetic code realized at elementary particle level?

The assumption was that water -possibly in liquid crystal like state- provides representations of molecules and in this manner makes possible water memory, frequency imprinting.

The hierarchy of Planck constants has brought additional details to this picture.

There is experimental evidence for what might be called dark hydrogen associated with water. The chemical formula of water is $H_{1.5}O$ in atto-second time scale and this could be explained if 1/4 of hydrogens are in dark phase. The dark portion of water could explain the numerous anomalies of water as a condensed matter phase. Water memory can be assigned with the magnetic bodies of the water molecule clusters and braiding would again be an excellent candidate for memory representations. Cyclotron Bose-Einstein condensate provide representation of water memory as temporal radiation patterns. They could be generated in the liquid flows inducing braiding. An interesting idea is that archetypal liquid flows are selected as asymptotic self-organization patterns and are accompanied by characeristic radiation patterns making possible "naming" of these patterns and symbolic dynamics.

A simple model for dark nucleons, their states of dark predicts that the dark nucleon states are in one-one correspondence with DNA, RNA, tRNA, and amino-acids in a natural manner

and that vertebrate genetic code emerges in a natural manner from the model. This suggests that genetic code is realized at nucleon level for the dark component of water and chemical realization is only secondary realization. This leads to a dramatic modification of views about the evolution of genome. It would not be anymore random choice followed by selection but much more like R&D in industry. The assumption that there is transcription of dark variants of the basic biomolecules to their chemical counterparts would make the new view possible. The basic mechanism of homeopathy would be basic mechanism of evolution allowing to modify genome as a response to environmental factors and also transfer the modifications to offspring.

The identification of bio-photons as ordinary photons resulting in the phase transition reducing the Planck constant assignable to dark photons is very natural and revises the model suggested in the article "A model for bio-photons" (see http://tinyurl.com/ycr4hvq2). Dark photons propagating along magnetic flux tube would play a key role also in the physics of biological body and brain and would provide an additional very fast communication channel besides nerve pulse transmission and various biochemical signalling mechanisms. This leads to a proposal for a model of cell membrane.

Direct experimental evidence for the notion of magnetic body carrying dark matter

The list of nice things made possible by the magnetic body is impressive and one can ask whether there is any experimental support for this notion. The evidence from water memory has been already mentioned. An explanation for the impressive list of anomalies of water [D17] discussed in [K49] provide one possible manner to justify the notion. For instance, it is known that in attosecond time scales water behaves as $H_{1.5}O$ [D16, D24, D13] as if part of hydrogen atoms would be dark.

The findings of Peter Gariaev and collaborators give evidence for the representation of DNA sequences based on the coding of nucleotide to a rotation angle of the polarization direction as photon travels through the flux tube and for the decoding of this representation to gene activation [I54], for the transformation of laser light to light at various radio-wave frequencies having interpretation in terms of phase transitions increasing \hbar [I7], and even for the possibility to photograph magnetic flux tubes containing dark matter by using ordinary light in UV-IR range scattered from DNA [I86].

Fractal hierarchy of magnetic flux sheets and the hierarchy of genomes

The notion of magnetic body is central in the TGD inspired theory of living matter. Every system possesses magnetic body and there are strong reasons to believe that the magnetic body associated with human body is of order Earth size and that there could be an entire hierarchy of these bodies with even much larger sizes. Therefore the question arises what one can assume about these magnetic bodies. The quantization of magnetic flux suggests an answer to this question.

- 1. The quantization condition for magnetic flux reads in the most general form as $\oint (p-eA) \cdot dl = n\hbar$. If supra currents flowing at the boundaries of the flux tube are absent one obtains $e \int B \cdot dS = n\hbar$, which requires that the scaling of the Planck constant scales up the flux tube thickness by r^2 and scaling of B by 1/r. If one assumes that the radii of flux tubes do not depend on the value of r, magnetic flux is compensated by the contribution of the supra current flowing around the flux tube: $\oint (p eA) \cdot dl = 0$. The supra currents would be present inside living organism but in the faraway region where flux quanta from organism fuse together, the quantization conditions $e \int B \cdot dS = n\hbar$ would be satisfied.
- 2. From the point of view of EEG especially interesting are the flux sheets which have thickness L(151) = 10 nm (the thickness of cell membrane) carrying magnetic field having strength of endogenous magnetic field. In absence of supra currents these flux sheets have very large total transversal length proportional to r^2 . The condition that the values of cyclotron energies are above thermal energy implies that the value of r is of order 2^{k_d} , $k_d = 44$. Strongly folded flux sheets of this thickness might be associated with living matter and connect their DNAs to single coherent structure. One can of course assume the presence of supra currents but outside the organism the flux sheet should fuse to form very long flux sheets.

3. Suppose that the magnetic flux flows in head to tail direction so that the magnetic flux arrives to the human body through a layer of cortical neurons. Assume that the flux sheets traverse through the uppermost layer of neurons and also lower layers and that DNA of each neuronal nuclei define a transversal sections organized along flux sheet like text lines of a book page. The total length of DNA in single human cell is about one meter. It seems that single organism cannot provide the needed total length of DNA if DNA dominates the contribution. This if of course not at all necessarily since supra currents are possible and outside the organism the flux sheets can fuse together. This implies however correlations between genomes of different cells and even different organisms.

These observations inspire the notion of super- and hyper genes. As a matter fact, entire hierarchy of genomes is predicted. Super genes consist of genes in different cell nuclei arranged to threads along magnetic flux sheets like text lines on the page of book whereas hyper genes traverse through genomes of different organisms. Super and hyper genes provide an enormous representative capacity and together with the dark matter hierarchy allows to resolve the paradox created by the observation that human genome does not differ appreciably in size from that of wheat.

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, K62].

- 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 [K47]. 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 [K62]. 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.

Years after writing this I decided to work out the model for dark DNA again and found that codons could be represented instead of 3-dark quarks also by 3 dark nucleons [L44] (see http://tinyurl.com/jgfjlbe). Effectively one only replaces u and d quarks with proton and neutron. This option is more promising that the original option.

8.2.7 How To Build A Quantum Computer From Magnetic Flux Tubes

Magnetic flux tubes play a key role in TGD inspired model of quantum biology. Could the networks of magnetic flux tubes containing dark particles with large \hbar in macroscopic quantum states and carrying beams of dark photons define analogs of electric circuits? This would be rather cheap technology since no metal would be needed for wires. Dark photon beams would propagate along the flux tubes representing the analogs of optical cables and make possible communications with maximal signal velocity.

I have actually made much more radical proposal in TGD inspired quantum biology. According to this proposal, flux tube connections are dynamical and can be changed by reconnection of two magnetic flux tubes. The signal pathways $A \to C$ and $B \to D$ would be transformed to signal pathways to $A \to D$ and $B \to C$ by reconnection. Reconnection actually represents a basic stringy vertex. The contraction of magnetic flux tubes by a phase transition changing Planck constant could be fundamental in bio-catalysis since it would allow distant molecules connected by flux tubes to find each other in the molecular crowd.

DNA as a topological quantum computer is the idea that I have been developing for 5 years or so. I have concentrated on the new physics realization of braids and devoted not much thought to how the quantum computer problems might run in this framework. I was surprised to realize how little I know about what happens in even ordinary computation. Instead of going immediately to Wikipedia I take the risk of publicly making myself fool and try to use my own brain.

What can one learn from ordinary computer programs

One could begin with the question what happens in classical computation. How the program is realized and how it runs? The notion of Turing machine (see http://tinyurl.com/7c4kl) represents an extreme abstraction mentioning nothing about the technical side and does not help much in attempts to answer these questions. Turing paradigm also assumes that program is a temporal sequence of operations. These operations could however correspond to a linear spatial sequences and inputs and outputs in this case would correspond to boundary values at the ends of the linear structure. This requires that the dynamics is such that evolution in spatial direction is analogous to a deterministic time evolution. In this case it is much easier to imagine biological realizations of quantum computer programs in TGD inspired bio-world.

To develop concrete ideas, one can start from the picture provided by ordinary computer program.

- 1. Programs consist of temporal/spatial sequences of commands and commands represent basic functions from which one can build more complex functions by the composition of functions having some numbers of input and output arguments. The eventual output variable can be expressed by printing of a piece of text or as an image in the computer screen. Each step in the program corresponds to a composition of functions: $f_{n+1} = g_{n+1} \circ f_n$. There is some minimal set of primitive/prime functions from which one builds up more complex functions by composition.
- 2. How this is realized at the level of hardware? One can assume that the basic functions are at some fixed places in the computer memory having addresses given by integers represented as bit sequences. This address represents the command - a name of the function. The names for input variables and output variables are bit sequences giving the addresses of the places containing the values of these variables. Program is a sequence of commands represented as bit sequences giving the address of the function to be computed at a given step and the addresses of inputs and outputs. As the processing unit reads the command, it generates/activates connections from the addresses of inputs to the address representing the function and from this address to the addresses of outputs.

Essentially the challenge is to reconnect, build/activate connections. An interesting question is whether learning identified as strengthening of synaptic connections (see http://tinyurl.com/cn7724o) [J7] is one particular example of this process.

- 3. How the sequence of bits representing command address is realized? As the processing unit reads the address of command it should automatically create/activate a connection from this address to the command address. The connections from the processing unit to the addresses could exist physically as wirings.
- 4. It is not necessary that program is dynamical so that the inputs and outputs would be initial and final values of variables. Inputs and outputs could also correspond to values of variables at the ends of a linear structure. In topological quantum computation space-like

entanglement would represent superposition of input-output pairs characterizing a function as a rule with instances represented as instances appearing in the superposition.

If this picture is roughly correct, re-connection would be the basic process. Reconnection is the basic process for magnetic flux tubes and $ADP \leftrightarrow ATP$ has been assigned to this process with ATP molecule serving as a relay activating the flux tube connection. Maybe ADP-ATP process, which is usually seen as a basic step of metabolism, could be seen as the core step for quantum computation performed by living matter. One expects that the presence ATP makes the rule represented by negentropic quantum entanglement conscious.

Quantum computation magnetic flux tubes as connections

Consider now quantum computation could take place in a circuitry having magnetic flux tubes as wires and some bio-molecules of groups of them as units defining prime functions. DNA as topological quantum computer could be taken as a starting point. The outcome of quantum computation is determined statistically as ensemble average so that a large number of copies of the program should be present and realized in terms of groups of cells or molecules connected by braidings if the quantum computation is space-like. This option seems more natural than time-like quantum computation realized as a 2-D liquid flow of lipids in the lipid layers of the cell membrane.

1. The hardware

Consider first the hardware of topological quantum computation using space-like braids.

- 1. Magnetic flux tubes would represent the wires along which inputs and outputs travel in the case of classical computation or dynamical quantum computation. In the case of space-like topological quantum computation entanglement is between the ends of the flux tubes.
- 2. Variables could be represented in many ways. For space-like quantum computations they could correspond to spin states of dark electrons at flux tubes or to polarization states of dark electrons at the flux tubes. In the original model of DNA as topological quantum computer quarks and antiquarks where proposed as a representation of genetic codons: also this quite science fictive option could make sense in TGD Universe since TGD predicts scaled versions of QCD like dynamics and presence of elementary particles in several p-adic scales and in scales dictated by value of Planck constant for given p-adic length scale.

The spin states of electron pair has been proposed as one possible representation of the 4 genetic codons. Quantum variables would be represented by qubit sequences and the measurement of qubit would give a bit sequence characterizing the classical value of the variable. Bio-molecules would be natural places for storing the values of the variables. For dynamical computations the values of variables could be transmitted using dark photons.

3. There would exist basic processing units calculating the prime functions from which more complex functions would be obtained as composites. Basic units could correspond to biomolecules. In the case of classical computation the inputs to molecules and outputs from them would travel along the flux tubes. In quantum computation these signals could be used to control the initial values of the variables. Molecules could also serve as gates for quantum computation.

2. Representation of programs

The basic program units in the case of quantum computation would be represented by braidings.

1. If the ends of braid strands are able to move freely when needed, it becomes possible to re-write programs. Lipid layers of cell membrane can be in liquid crystal state so that these are ideal for this purpose. The time-like braiding resulting from lipid flow and representing running topological quantum computation program would induce space-like braiding representing space-like topological quantum computation or a rule. A particular quantum computer program represented as space-like braiding of the flux tubes would result as liquid crystal melts for a moment and freezes again.

Protein aggretion process (see http://tinyurl.com/yarrblxn) in which proteins covered by ordered water analogous to ice temporarily melt and form aggregates [I23] is basic process induced by the feed of energy to the cellular system and could be compared to cellular summer. This process could mean quite generally molecular re-programming induced by the flow of cellular water inducing molecular flows inducing re-braidings. The braiding would also store the highlights of the cellular summer to cellular memory! This could be also seen learning by a modification of various quantum computer programs.

2. Negentropic entanglement is highly suggestive and would conform with the idea that the rule represented by entanglement represents conscious information or information which can become conscious. The process of becoming conscious information could involve $ATP \rightarrow ADP$ and de-activating the flux tube and destroy the information. Time-like braiding represented by liquid flow would modify space-like braiding.

It is not quite clear whether the information is conscious when negentropic entanglement (and ATP) is present - as Bohm's notion of active information (see http://tinyurl.com/qhx3suy) [J77] would suggest - or when ATP is transformed to ADP and connection becomes passive. Negentropic entanglement can be stable with respect to NMP (see http://tinyurl.com/yd3mly5m) [K80] so that the presence of ATP could mean period of conscious experience - negentropic entanglement could be analogous to active information.

TGD based model for the memory recall by sending negative energy signals to geometric past suggests that the absorption of negative energy photon transforms ATP to ADP. Conscious experience is regenerated in the geometric now where the negative energy signal came from - perhaps by transforming ADP to ATP by using the negative resulting by sending of negative energy signal! Conscious reading would be actually memory recall and analogous to teleportation? The destruction of the representation of memory in the geometric past would have interpretation in terms of no-cloning theorem (see http://tinyurl.com/2dh14oe) [B4].

3. Static realizations of the programs are easier to imagine since no temporal codes are needed for the transfer of bits. An attractive idea is that the computations are represented by static entanglements for linear structures and that time-like braiding allows to modify the programs.

3. The realization of program

The program would be basically a sequence of address lists. Address list would contain the address of the function to be performed and the addresses of the input molecules and output molecules. How to represent the address physically?

- 1. The simplest manner to realize this would use existing flux tubes connecting the processing unit to all possible input and output addresses as well as command addresses, and activate those flux tubes to which input and output data are assigned and reconnect them to the flux tubes connecting processing unit to the unit representing the function. The processing unit would have flux tubes coming from all possible inputs, going to all possible outputs, flux tubes going to places representing functions and coming from these places. Processing unit would be like a relay station or old fashioned telephone center whose sole purpose would be to create connections by reconnecting flux tubes. ATP molecule would be probably involved with the activation and - allowing a sloppy language - one could say that communication line becomes conscious when ATP is attached to it.
 - (a) Addressing would be just selection of activated molecules and analogous to that used in telephone network or computer network connected by cables. This would require static flux tube network and flux tubes could be either active or passive. In passive state flux tubes could be short-cut by a reconnection with hydrogen bond so that the ends of cut flux tube would end up to water molecules. This is however not necessary. Activation in absence of the short cut would involve reconnection of a flux tube with a flux tube connecting two parts of ATP - possibly hydrogen bond again- so that ATP becomes part of the flux tubes. If also short cut is involved, the strands coming to the two water molecules reconnect and generate hydrogen bond and flux tube to which ATP would

attach in the proposed manner. As ATP is used it transforms to ADP and de-attaches from the flux tube.

- (b) One can imagine also a dynamical addressing based on the generation of magnetic flux tubes between inputs and submodules. The computational process could be still space-like. The first manner to realize dynamical addressing would be by attaching to the ends of dynamical flux tubes biomolecules, which bind to specific receptors. Receptor mechanism would allow to connect distant cells to each other and build a magnetic flux tube connection between them. Computational unit specialized to run a specific program could excrete biomolecules binding to the input and output receptors: this program would realized function in terms of space-like entanglement. Glands (see http://tinyurl.com/cxjro9z) excrete hormones binding to receptors and various glands could in principle serve as computational units. Various information molecules bind very selectively and this might also relate to quantum space-like computations.
- (c) Second mechanism of dynamical addressing would use dark photons. In this case resonant interaction selecting the target would replace the receptor mechanism. In this kind of situation one can claim that flux tubes are un-necessary, one can use just resonance to build connection to a desired place just as one does in radio communications. Of course, topological light rays could be accompanied by flux tubes. For instance, DNA nucleotide could attach by flux tube to its conjugate in distant DNA molecule and if the connection is based on resonance only similar nucleotide sequences could connect with each other. I have discussed this kind of mechanism in a model for remote replication of DNA (see http://tinyurl.com/ybvosy7h) [K149] based on the experimental work by Peter Gariaev and his group. The resonance mechanism could also make possible to establish flux tube connections and the quantum computation could be a static operation.
- 2. DNA as topological quantum computer vision gives some idea about how the computer program could be realized as a spatial linear structure.
 - (a) Program would be a sequence of topological quantum computations. Given topological quantum computation would be represented by a braiding of flux tubes connecting DNA nucleotides with the lipid molecules of the inner lipid layer. Program would correspond to a linear sequence of cells with the outer lipid layer connected to the DNA of the second cell.
 - (b) Lipid flows at given lipid layer could be used to rewrite programs and the programs could respond to the changes in environment in this manner: this would require that the lipid layer is in liquid crystal state during the period when program is changed. Also nerve pulse patterns would induce these flows. Programs would also represent memories as rules realized as quantum abstractions or as quantum functions.
 - (c) The program would "run" in the spatial direction. The selection of active input and output variables would be by acting the connection from molecule in question by attaching ATP as a relay through which the reconnected flux tube would traverse. This would be also part of the writing of the program. The superposition of entangled inputs and outputs could be seen as a quantum superposition of classical programs assigning outputs to inputs. Also microtubule-lipid layer braiding suggested also to play a key role in the realization of memories could give rise to similar space-like quantum computation representing rules.
 - (d) The effective 2-dimensionality implied by strong form of holography implied in turn by strong form of general coordinate invariance means that the physics depends on partonic 2-surfaces and 4-D tangent space data at them. This suggests that the dynamics on space-like 3-surfaces and light-like orbits of partonic 2-surfaces is fixed by a process analogous to gauge selection. Does just this effective gauge symmetry make possible to write quantum computer programs? Already ordinary deterministic computer program means selection of one particular dynamics from several alternative options suggesting that strict determinism is broken.
- 3. What could be the role of bio-catalysis in the computation? Bio-catalysis is a central part of the biological information processing and it would not be surprising if the catalysts connected by flux tubes to substrate molecules were involved with the computations. An attractive idea is that various information molecules binding to receptors involved with bio-control (neurotransmitters, hormones, etc...) are involved with building the flux tube connections between cells. These bio-molecules could carry the ends of flux tubes to special places for which receptors serve as addresses and in this manner build hardware for topological quantum computation involving inputs and outputs in distant parts of the body. The final output could be transformed to controlled gene expression. Quite generally, catalysts bind very selectively and could play a role similar that played by information molecules in building up the quantum computer programs.
- 4. One can imagine also purely classical computation based on catalytic mechanism probably allowing generalization to quantum case. The idea is that computer program - understood now as dynamical structure - is analogous to what happens in fairy tale in which hero finds a key which fits to a lock of a room containing a key which... There exists a beautiful realization of classical computation in terms of chemical concentrations using DNA. The output of given reaction representing computational step appears in the next reaction provide the system contains additional participating molecules, which could be both substrate molecules and catalysts. The program could be represented as concentrations of molecules needed at intermediate steps and lock-to-key mechanism guarantees that they are performed in the correct temporal order. Inputs and output molecules could be connected by flux tubes to bio-molecules which bind to specific receptors associated with the molecule representing the particular subprogram. This would automatically create a large number of classical computations proceeding in fixed order, maybe even quantum computations.

8.2.8 DNA As Topological Quantum Computer

The vision about how DNA might act as a topological quantum computer (TQC) [B16] is few years old [K6]. TQC means that the time-like braidings of braid strands define TQC programs and M-matrix (generalization of S-matrix in zero energy ontology) defining the time-like entanglement between states assignable to the end points of strands define the TQC program coded as unitary time evolution for Schrödinger equation in the standard framework. One can end up to the model in the following manner.

- 1. Darwinian selection for which the standard theory of self-organization provides a model, should apply also to TQC programs. TQC programs should correspond to asymptotic self-organization patterns selected by dissipation in the presence of metabolic energy feed. The spatial and temporal pattern of the metabolic energy feed characterizes the TQC program or equivalently sub-program call.
- 2. Since braiding characterizes the TQC program, the self-organization pattern should correspond to a hydrodynamical flow or a pattern of magnetic field inducing the braiding. Braid strands must correspond to magnetic flux tubes of the magnetic body of DNA. If each nucleotide is transversal magnetic dipole it gives rise to transversal flux tubes, which can also connect to the genome of another cell. As a matter fact, the flux tubes would correspond to what I have used to call wormhole magnetic fields [K147] having pairs of space-time sheets carrying opposite magnetic fluxes. The wormholes themselves could have interpretation as dark scaled variants of ordinary elementary particles. The large value of Planck constant would zoom up the magnetic fields associated with ordinary elementary particles from weak scale to much longer length scale given by cell size or even a longer length scale.
- 3. The output of TQC sub-program is probability distribution for the outcomes of state function reduction so that the sub-program must be repeated very many times. It is represented as four-dimensional patterns for various rates (chemical rates, nerve pulse patterns, EEG power distributions, ...) having also identification as temporal densities of zero energy states in various scales.

By the fractality of TGD Universe there is a hierarchy of TQCs corresponding to p-adic and dark matter hierarchies. Programs (space-time sheets defining coherence regions) call programs in shorter scale. If the self-organizing system has a periodic behavior each TQC module defines a large number of almost copies of itself asymptotically. Generalized EEG could naturally define this periodic pattern and each period of EEG would correspond to an initiation and halting of TQC. This brings in mind the periodically occurring sol-gel phase transition inside cell near the cell membrane. There is also a connection with hologram idea: EEG rhythm corresponds to reference wave and nerve pulse patterns to the wave carrying the information and interfering with the reference wave.

- 4. Fluid flow would naturally induce the braiding which requires that the ends of braid strands must be anchored to the fluid flow. Recalling that lipid mono-layers of the cell membrane are liquid crystals and lipids of interior mono-layer have hydrophilic ends pointing towards cell interior, it is easy to guess that DNA nucleotides are connected to lipids by magnetic flux tubes and hydrophilic lipid ends are stuck to the flow. Also nerve pulse patterns could induce the flow of lipids inducing the braiding so that nerve pulse patterns would define TQC programs and be coded into memories.
- 5. The topology of the braid traversing cell membrane cannot be affected by the hydrodynamical flow. Hence braid strands must be split during TQC. This also induces the desired magnetic isolation from the environment. Halting of TQC reconnects them and make possible the communication of the outcome of TQC.

This is one possible realization and it is of course clear that one can imagine several alternatives. There are several problems related to the details of the realization.

- 1. How nucleotides A, T, C, G are coded to the strand color and what this color corresponds to physically? The original proposal was that there are two options which could be characterized as fermionic and bosonic.
 - (a) Magnetic flux tubes having quark and anti-quark at their ends with u, d and u_c , d_c coding for A, G and T, C. CP conjugation would correspond to conjugation for DNA nucleotides.
 - (b) Wormhole magnetic flux tubes having wormhole contact and its CP conjugate at its ends with wormhole contact carrying quark and anti-quark at its throats. The latter are predicted to appear in all length scales in TGD Universe.

Recently it became clear that there is much simpler realization involving only spin 1/2 fermion pairs assignable to pairs of flux tubes. The spin states of fermion pairs form triplet and singlet and code for A, T, C, G. The first guess is that fermion is proton or electron but this does not allow coding of color qualia. Taking fermion to be u quark one can realize color qualia in terms of quark color and has good hopes about Coulomb stability since the charge assigned to nucleotide reduces from -2 to -2/3 (Coulomb stability of DNA is a well-known problem). Flux tubes are ordinary flux tubes. One ends up also to a concrete model for happens when color qualia are generated. An unexpected bonus is that statistics constraint implies that color and spin entanglement forces spatial entanglement realized as braiding of the flux tubes so that entanglement indeed has classical space-time correlate.

- 2. How to split the braid strands in a controlled manner? High T_c super conductivity provides a possible mechanism: braid strand can be split only if the supra current flowing through it vanishes. A suitable voltage pulse induces the supra-current and its negative cancels it. The conformation of the lipid controls whether it it can follow the flow or not.
- 3. How magnetic flux tubes can be cut without breaking the conservation of the magnetic flux? The notion of wormhole magnetic field could save the situation now: after the splitting the flux returns back along the second space-time sheet of wormhole magnetic field. An alternative solution is based on reconnection of flux tubes. Since only flux tubes of same color can reconnect this process can induce transfer of color: "color inheritance": when applied at the level of amino-acids this would give strong constraints on the model of protein

folding [K10]. Reconnection makes possible breaking of flux tube connection for both the ordinary magnetic flux tubes and wormhole magnetic flux tubes.

4. How magnetic flux tubes are realized? The interpretation of flux tubes as correlates of directed attention at molecular level suggests a rather concrete picture. Hydrogen bonds are by their asymmetry natural correlates for a directed attention at molecular level. Also flux tubes between acceptors of hydrogen bonds must be allowed and acceptors can be seen as the subjects of directed attention and donors as objects. Examples of acceptors are aromatic rings of nucleotides, O = atoms of phosphates, etc.. A connection with metabolism is obtained if it is assumed that various phosphates XMP, XDP, XTP, X = A, T, G, C act as fundamental acceptors and plugs in the connection lines. The basic metabolic process $ATP \rightarrow ADP + P_i$ allows an interpretation as a reconnection splitting flux tube connection, and the basic function of phosphorylating enzymes would be to build flux tube connections as also of breathing and photosynthesis.

The model makes several testable predictions about DNA itself. In particular, matterantimatter asymmetry and slightly broken isospin symmetry at the level of dark quarks have counterparts at DNA level induced from the breaking of these symmetries for quarks and antiquarks associated with the flux tubes. DNA cell membrane system is not the only possible system that could perform TQC like activities and store memories in braidings: flux tubes could connect biomolecules and the negentropic braiding could provide an almost definition for what it is to be living. Even water memory might reduce to braidings.

The model leads also to an improved understanding of other roles of the magnetic flux tubes containing dark matter. Phase transitions changing the value of Planck constant for the magnetic flux tubes could be key element of bio-catalysis and electromagnetic long distance communications in living matter. There is also a fascinating connection with Peter Gariaev's work [I86] suggesting that the phase transitions changing Planck constant have been observed and wormhole magnetic flux tubes containing dark matter have been photographed in his experiments [K135].

8.2.9 What Is The Role Of Magnetic Body In DNA Replication, Mitosis, Meiosis, And Fertilization?

If magnetic body uses biological body as a motor instrument and sensory receptor, the natural question is whether basic process such as mitosis, meiosis. could be induced by more fundamental processes for the magnetic body. One can argue that if magnetic flux tubes are responsible for making living organism and even population a kind of Indra's net, cell division should be induced by magnetic body and should produce automatically this Indra's net.

As a matter of fact, cell division brings strongly in mind division of magnetic dipole but also the reconnection of magnetic flux tubes can be considered as a basic mechanism. At least the following basic mechanisms can be considered.

- 1. Consider a pair of magnetic flux tubes with opposite fluxes connecting objects A and B. The division of A+B to A and B would be induced by a reconnection process for the members of the pair producing two loops associated with A and B but no connection between A and B anymore. The problem of this option is that the flux tube connection defined in this manner might not be stable enough.
- 2. Magnetic dipole would correspond to a flux tube at the core of the dipole field itself decomposing to flux tubes with weaker magnetic flux at its ends. The division to two dipoles would correspond to a formation of segment in which flux tube decomposes into several flux tubes, which need not be parallel anymore. Two new dipole ends are formed and the old dipole ends remain connected so that the repetition of this process would yield a kind of Indra's net predicting that all cells of living organism are connected by the flux tubes to single coherent whole.

The division of flux tube to several flux tubes could also correspond to the increase of Planck constant by integer factor n along a segment of flux tube. The resulting n flux sheets would corresponds to the sheets of the covering. The length of the segment would be scaled up by n.

3. If one has pair of dipoles A-B and C-D with same total flux, a reconnection leading to A-D and C-B is possible.

Could biochemical processes associated with cell division be induced by some of the listed processes? The two latter options would predict that the cells produced in cell division remain connected by magnetic flux tubes. The division of dipole creates two new dipole ends connected by short flux tube. The already existing ends remain connected by "long" flux tubes carrying weak magnetic fields as compared to that carried by the dipole itself. Also the processes of meiosis and fertilization could respect the presence of long flux tubes connecting the cells participating in the process so that flux tube connections could also exist between parents and offspring. The members of population could form a kind of super-organism. Remote interactions between DNA and other biomolecules of closely related members of species and even shared use of DNA (and its TGD variant "dark DNA") can be imagined.

- 1. Consider first DNA replication and reshuffling taking place in meiosis (see http://tinyurl. com/25jmwu) [I18] essential for the sexual reproduction in eukariotes. The dividing nucleus (of form MMFF) is ordinary nucleus and contains two pairs of chromosomes coming both mother (MM) and father (FF). Division produces four haploid cells containing only two chromosomes (AB) with A and B obtained by reshuffling the DNAs of mother and father to obtained 4 unique chromosome pairs. In sexual reproduction these cells fuse to form diploid cells (MMFF).
 - (a) The reshuffling of a pair MF of DNA strands from father and mother could be induced by a repeated reconnection process for flux tubes parallel to DNA strands. The simplest reconnection for strands A-B and C-D produces strands A-X-D and C-Y-B where A-Z and C-Y are pieces of A-B and C-D with same number of codons.
 - (b) The replication of DNA takes place for all four chromosomes before reshuffling. One obtains a nucleus containing 4 pairs of doubled chromosomes. This double nucleus divides to two daugher nuclei containing 2 doubled chromosomes each. These divide further to two nuclei each containing only two chromosomes each (AB). The DNA reshuffling could correspond to a multiple reconnection process if the two DNA takes and the last the last takes and tak
 - DNA strands are accompanied by by long magnetic dipoles (flux tubes). Note that in absence of additional restrictions many combinations (28) are possible.(c) After replication and reshuffling the division of the nucleus two two intermediaries could
 - be induced either by splitting of a flux tube connecting pairs of doubled chromosomes to flux tubes not anymore parallel to each other. The flux could diverge to a larger volume in this segment. Second possibility is that the increase of Planck constant increases the length of segment and at the same time divides the flux into sub-fluxes. Dipole field flux tube would give long flux tubes and split dipole shorter flux tubes connecting the resulting cells together.
 - (d) Also the chromosome pairs of the resulting intermediate nuclei could be connected to each other by flux tubes to form a connected structure A-B-C-D and reconnection process could divide it to A-B plus C-D (say) and lead to a division of the nucleus producing 4 ordinary daughter nuclei.
- 2. In mitosis (see http://tinyurl.com/691fln) [I19] the initial nucleus corresponds to MMFF and DNA replication leads to pairs of doubled chromosomes but without re-shuffling. One doubled pair from mother and one pair from father the members of doubled chromosomes are connected by a kind of bridge. In the mitosis proper the doubled chromosome pairs are split and two chromosome pairs containing one chromosome from father and mother are formed. After this division leads to two diploid cells similar to the dividing cell.
- 3. In fertilization (see http://tinyurl.com/2tzd6k) [I12] gametes from father and mother fuse together to form a single cell with two pairs of chromosomes from both father and mother. The question is how the two gametes are able to find each other. The reconnection of closed magnetic flux tubes associated with the gametes could lead to a formation of bridges connection the two gametes and a phase transition reducing the value of Planck constant could lead the two gametes near each other and make possible the fusion.

DNA replication (see http://tinyurl.com/2tbv2d) [I10] is clearly the fundamental process, and the question is whether also this step could be reduced to a reconnection for a pair flux tubes: first would connect the separated DNA strands and second one free nucleotide and its conjugate.

- 1. Suppose that there are flux tubes connecting nucleotides of DNA and corresponding nucleotides of the conjugate strand: they could be rather short flux tubes of length shorter than 1 nm in the normal situation but could grow longer when DNA strands separate. This might involve a phase transition increasing temporarily the value of Planck constant assignable to these flux tubes and increasing the length of the segment and of connecting flux tube and therefore the distance of DNA strands.
- 2. There are also free DNA nucleotides and their conjugates in the environment which can be used in the replication process as building bricks. If also free nucleotides and their conjugates are connected in a pairwise manner by similar flux tubes and if the value of magnetic flux characterizes a given pair then reconnection could take place for these two kinds of flux tubes and lead to a correct pairing of DNA strand with conjugate nucleotides. Same would happen for the conjugate strand. The reduction of Planck constant would lead to a pair of ordinary DNA double strands.
- 3. The details of the dynamics would be determined by other factors but the outcome would be fixed by the nucleotide-conjugate pairing and dependence of the flux on the nucleotide pair. In particular, conservation of magnetic flux would guarantee that the nucleotides can be assigned only with their conjugates.

These arguments suggest that reconnection of magnetic flux tubes, temporary change of the Planck constant, and coding of nucleotide-conjugate pairs by magnetic flux could be key element of meiosis, mitosis, and reshuffling of chromosomes in meiosis. Also higher level processes - such as cell division and fertilization - could involve reconnection process as a fundamental step. These mechanisms would appear in several length scales corresponding to DNA, nucleus, and cell length scale. In an approach based on mere chemistry, this must be assumed as a result of kinematics.

8.2.10 Three pieces of evidence for the notion of magnetic body

Evidence for the notion of magnetic body has started to accumulate. The following discusses three rather recent pieces of evidence.

Evidence for the notion of magnetic body from brain synchrony without corpus callosum

The notion of magnetic body is central for the entire TGD based approach to living matter and it would be important to find experimental support for it. Quite recently I received a link to a rather baffling finding about brain [J57] (see http://tinyurl.com/3gjhtgb). Neuroscientists have believed that the two hemispheres communicate via the neural pathways associated with corpus callosum: kind of communication cables would be in question. Many areas of brain behave synchronously, which has led to the notion of resting state network.

The team led by Michael Tyszka, associate director of Caltech Brain Imaging Center, has however discovered that the resting state network seems to work normally in people born without corpus callosum! As if brain hemispheres were communicating by some other means than neural signalling! This finding challenges not only the views about the origin of brain synchrony as being created by neural circuits but also the models of autism and schizophrenia explaining them in terms of impaired communications between hemispheres.

One can for instance speculate with the possibility that there is electromagnetic communication between brain hemispheres. This does not look a bad idea at all: nowadays it is possible to extract information about EEG so that pilots are able to control the flight of tiny flying object by imagining what the object should do. Technological applications will probably appear in the market soon so that anyone can have robots controllable by thoughts.

This mechanism is consistent with the TGD inspired view about brain. This view however encourages to consider also a more imaginative explanation. In TGD Universe living system involves besides organism and environment also magnetic body (MB) acting as an intentional agent receiving sensory input from organism and controlling it. MB has hierarchical onion-like structure. For instance, brain hemispheres have their own MBs, and entire brain its own MB serving as a "boss" for the MBs of hemispheres.

Communications between magnetic body and part of organism take place using dark photons having non-standard value $h_{eff} = n \times h$ of Planck constant and thus energy $E = h_{eff}f$, which should correspond to ordinary photons with energies above thermal energy: otherwise quantal effects are masked by thermal fluctuations. Bio-photons in the visible and UV range could result in the transformation of dark photons to ordinary photons. The frequency range of dark photons depends on the level of the layer of MB characterized by h_{eff} and wavelength corresponds to the size scale of the layer.

In the case of brain the transfer of sensory information to MB would be realized as EEG wavelength of 7.8 Hz radiation is order of the circumference of Earth so that MBs for brain would be really large. In Zero Energy Ontology (ZEO) control signals would be realized as negative energy signals propagating backwards in geometric time and having phase conjugate laser light as a counterpart in ordinary physics. This explains Libet's finding that neural activity precedes conscious decision. Coordination by using EEG rhythms would be part of control analogous to work songs.

The MB of entire brain controls it and could naturally do this via the intermediate control of brain hemispheres forcing them to operate in the same rhythm. Brain synchrony and resting network would not be produced by resonant neuro-circuits as usually believed but by the spatiotemporal coherence of the EEG radiation from the MB of entire brain forcing brain hemisphere MBs to oscillate in the same rhythm and in turning synchronizing the brain hemispheres. This would be like forcing soldiers to march in the same pace and brain hemispheres could co-operate without any neural communication between hemispheres. The communication between hemispheres would be needed for more refined collaboration involving "discussion" between hemispheres: hemispheres of a person without corpus callosum would be like soldiers obeying blindly the orders. This might be also an essential element of autism and schizophrenia.

Magnetic body and magnetic sense

Humans seem to have sixth sense: kind of sub-conscious magnetic sense of directions (see http: //tinyurl.com/j8rqskj) possessed by many animals lower in the evolutionary tree - in particular birds and fishes and also many mammals. There is evidence that also humans but not all of us and not always - seem to respond to magnetic field.

Geophysisicist Joe Kirschwink working at CalTech as professor of geobiology is already familiar to me. For instance, Kirscwink has introduced the term "snowball Earth". Kirscwink claims that he has proven that also humans have magnetic sense serving as a kind of compass. The experiment involves a slowly rotating constant magnetic field with strength between .25-.6 Gauss (Earth's magnetic field has nominal value of .5 Gauss and the "endogenous" magnetic field appearing in TGD inspired quantum biology has value about .2 Gauss). The field is created by coils located at the walls of a cube s o that its direction is under control and it can be also cancelled. The subject person sits in the middle of a Faraday cage eliminating electromagnetic perturbations from environment ad her EEG is measured. The explanation for why the earlier experiments often failed is that external perturbations cancelled the effect.

What was found that when the applied field rotates counterclockwise there is a response: the intensity in EEG alpha band drops down. The response however appears few hundred milliseconds later than one would expect if the response is passive response due to the electric currents induced by the applied field in brain. The signal appeared for up-down direction and counter-clockwise rotation but not the opposite. It also appeared when the direction of the field "yawed into the floor". I take yaw to mean the orientation angle of magnetic field with respect to the vertical axis.

A slow counterclock-wise rotation of the applied field was necessary. It was not mentioned how slow this rotation was. The rotation of the applied field mimicked the effect produced by the rotation of head with respect to the magnetic field of Earth, which is in good approximation nonrotating in the inertial frame of person. In TGD framework one can ask whether parity breaking effect in macroscopic length scales was involved. What comes in mind is the rotation of the water going down to drain taking always in clocwise direction. Magnetic field obeys same equation as incompressible hydrodyamic flow. Could it be that the magnetic field associated with magnetite sensors in magnetic receptor neurons rotates in clockwise direction much like water going in drain and the response is maximal when the rotation directions are opposite?

One can probably invent purely neuroscientific explanations for the time lag of few hundred milliseconds for EEG response (EEG consists of quasistationary pieces of duration about .3 seconds possibly identifiable as correlates of mental images). In TGD framework the lag could be understood i as being due to the fact that the percept is communicated to MB responding by reducing the alpha wave responsible synchronization of the brain. This response could be kind of wake-up from synchrony.

Does the magnetic body of Earth protect planet's atmosphere from cosmic rays?

Third piece of evidence for MB comes from NASA (see http://tinyurl.com/j57h32u). MIT scientists have found what the article calls mysterious "invisible" force field protecting planet's atmosphere by preventing cosmic ray radiation entering to the lower atsmosphere. The field was first noticed by two NASA spacecrafts orbiting in van Allen radiation belt at height of 11,000 km (Earth radius is 6,371 km). The field blocks highly radioactive higher energy electrons. These electrns are attracted towards Earth by the magnetic field of Earth but cannot approach planet closer than 13,300 km - slightly more than twice the Earth radius.

Low frequency electromagnetic fields are involved as with dark matter at magnetic bodies. My guess is that the guardian angel is the magnetic body of Earth carrying dark matter to which one can assign magnetic field strength of .2 Gauss (2/5 of the nominal value of the Earth's magnetic field): actually entire spectrum of values is expected. The flux tubes or sheets carry dark matter and it could absorb the cosmic rays and tame them to Bose-Einstein condensates. For large $h_{eff} = n \times h$ the high energy E of cosmic ray corresponds to very low frequency $f = E/h_{eff}$ and very long wavelength of order Earth size scale. Ordinary cosmic ray would be transformed to dark cosmic ray with very long wave length. The effect of ordinary cosmic ray is in scale of wavelength and highly local and disastreous for biomolecules like DNA. Now the affect would be absent. Dark magnetic body would act like mattress.

8.3 The Relationship Between Information Processing And Metabolism In TGD Universe

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.

8.3.1 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 [K26]. Electronic superconductivity 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 [K48] 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 cycloctron 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 [K55]. 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 comes are 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 ~ 2¹¹. 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 $r = \hbar/\hbar_0 = 1836 = 4 \times 3^3 \times \times 17$ 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 μ 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 [K80]. Quantum arithmetics [K92] 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 [K92]. One implication is an explanation for Shnoll effect [K11], 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. ?? 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 ineed 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?

8.3.2 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 [I77, I29, I25, I11]. The ideas about the detailed relationship between metabolism and negentropic entanglement are still in a state of turmoil. Let us sum up those concepts and ideas which could serve as starting point.

1. Negentropic entanglement is the first basic notion. There is a strong tendency to consider the presence of a magnetic flux tube connecting two objects and carrying negentropically entangled quantum state as a fundamental structure giving rise to a directed attention. Negentropic entanglement would be basic element of conscious cognition, and one can assign to it various attributes like experience of understanding. The mildest assumption is that negentropic entanglement is associated with the flux tube. A stronger assumption is that it is between states assignable to the ends of the flux tube identifiable as observer and target of attention.

An analogy with Orch OR is suggestive. The period of negentropic entanglement - period of directed attention - would correspond to Orch Or and its end to state function reduction.

2. Negentropic entanglement 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.

- 3. An attractive interpretation is that the presence of ATP at magnetic flux tube serves as a signature of negentropic entanglement. The period of negentropic entanglement could be seen as the analog of Orch OR period ending with state function reduction. This period would be accompanied by consciousness to which one can assign various attributes such as experience of understanding and positively colored emotions. It is of course difficult to say what the counterparts of these experiences are at the level of flux tubes. One can imagine two options.
 - (a) The high energy phosphate bond in ATP is the carrier of the negentropic entanglement. The transformation of ATP to ADP would liberate the metabolic energy and mean end of the period during which one can assign negentropic entanglement to the flux tube. ATP would be the correlate for consciousness at the flux tube level - the molecule of consciousness.
 - (b) ATP \rightarrow ADP transfers metabolic energy quantum to the magnetic flux tube and creates a excited with negentropic entanglement. This process could correspond to either generation of negentropic entanglement (period of negentropic entanglement would begin with ATP \rightarrow ADP rather than end) or transfer of it from ATP to the flux tube.
- 4. 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 pairs or provide the metabolic energy needed to re-arrange the flux tube connections between distant molecules by $ADP + P_i \rightarrow ATP$ process?
- 5. The identification of the increments zero point kinetic energies as universal metabolic energy quanta is one of the oldest hypothesis of TGD inspired theory of consciousness. Zero point kinetic energy is associated with the zero point motion of particle at space-time sheet. The finite size of the space-time sheet gives rise to this energy for which non-relativistic parameterization is $E_0 = k \times 3\hbar^2 \pi^2 / 2mL^2(k)$. $L(k) = 2^{(-k+151)/2}L(151)$, $L(151) \simeq 10$ nm is the p-adic length scale of the space-time sheet, and k numerical factor not far from unity. Particle in 3-D box gives k = 1.

As particle is transferred to a larger space-time sheet the zero point kinetic energy is reduced, and the difference is liberated as usable metabolic energy. For proton the size scale of this space-time sheet could be atomic size scale k = 137. For electron it could electron Cooper pair k = 149 (prime) corresponding to a lipid layer of cell membrane could be in question. Entire hierarchy of metabolic energy quanta is predicted and the energy scale depends on the particle mass and p-adic length scale and geometric factors characterizing the shape of space-time sheet only.

One can ask whether the high energy phosphate bond in the phosphate of ATP molecule contains this kind of smaller space-time sheet and in the transition ATP \rightarrow ADP, electron or proton drops from this kind of space-time sheet. The following considerations show that this hypothesis is not necessary, and that one can also modify the identification of the fundamental metabolic energy quantum as zero point kinetic energy without losing anything. Therefore the details of the scenario are far from being fully nailed down.

- 6. Magnetic flux tubes are carriers of charged particles and the hypothesis is that cyclotron Bose-Einstein condensates for fermionic Cooper pairs and bosonic ions are relevant for consciousness. In particular, cyclotron transitions in which bosons in these condensates are excited would be important for the generation of conscious experiences. The hierarchy of Planck constants and the fact that cyclotron energy is proportional to \hbar allows to have arbitrarily high cyclotron energies in given magnetic field. This is essential in the model for the effects of ELF em fields on living matter [K17].
- 7. Becker's finding about the relevance of DC currents for healing of wounds lead to an idea about how electromagnetic radiation interacts with the charged particles at magnetic flux

tubes [L24]. What would happen is that charged particles experience the electric and magnetic fields of the radiation field described in terms of massless extremals (topological light rays). Electric field would generate acceleration in the direct of the flux tube and could excite Becker currents which would give rise to biological effects - healing of wound in the simplest case. The proposal has been that this process gives rise to what could be seen as a loading of metabolic batteries.

The combination of this view with the notion of cyclotron BE condensate leads to a slightly more complex picture. Radiation field can excite single boson states both in transversal and longitudinal degrees of freedom. Transversal ones correspond to cyclotron states with energies $E_{c,n} = (n + 1/2)E_c$, $E_c = \hbar q B/m$ and the energies of excitations are of form nE_c . Longitudinal degrees of freedom correspond to a particle in 1-D box -possibly in presence of longitudinal electric field: a simple model for the states was derived in the model for Becker's DC currents.

In the absence of longitudinal electric field the energy spectrum is $E_n = n^2 E_0$, $E_0 = \hbar^2 \pi^2 / 2mL^2$, L the length of the flux tube. Longitudinal excitations correspond to energies $(n_f - n_i)^2 E_0$ and would classically correspond to the acceleration in the electric field component parallel to the flux tube giving rise to Becker currents. For both excitations negentropically entangled states result very naturally as superpositions of single particle excitations and possibly also multi-particle excitations. Both incoming photons and liberation of metabolic energy quantum as photon can induce the excitation.

One could reinterpret the idea about universal metabolic energy quanta by interpreting them as increments of longitudinal energies at flux tube. For the excitation $n = 1 \rightarrow 2$ the energy would be $3\hbar^2\pi^2/2mL^2$ which is same as zero point kinetic energy for a particle in 3-D box of side L. Quantitative prediction is therefore same as that of the original model. One can of course consider also the original option that the transfer of particles from the flux tube to a larger space-time sheet indeed liberates metabolic energy.

Let us now try to weave these ideas to an internally consistent picture. It is perhaps best to proceed by making questions.

- 1. Could one assign negentropic entanglement with high energy phosphate bond? If so, the period of negentropic entanglement (having Orch OR as a counterpart) would correspond to the presence of ATP and the end of this period to $ATP \rightarrow ADP$. I have considered this possibility earlier. The problem is that it is difficult to understand how negentropic entanglement could be assigned simultaneously both to ATP and to the magnetic flux tube whose length and thickness are proportional to \hbar and therefore varies. One should treat ATP and flux tube as single basic structure and this does not sound convincing since the scales of flux tubes are expected to be much longer than the size scale of ATP molecule. Therefore there are two options.
 - (a) ATP is just what it is believed to be: provider of metabolic energy only. One can leave also open the question whether high energy phosphate bond can be interpreted in terms of zero point kinetic energy or not.
 - (b) ATP carries both metabolic energy and negentropic entanglement assignable to the phosphate bond and metabolic energy corresponds to zero point kinetic energy difference. In $ATP \rightarrow ADP$ a possibly dark photon or photons are emitted and is absorbed by a magnetic flux tube containing cyclotron Bose-Einstein condensate and the resulting de-localized single particle excitation as quantum superposition of various single particle excitations carries negentropic entanglement in the length scale associated with the magnetic flux tube, which can be much longer. Even several flux tubes could be excited simultaneously. This would regenerate long range negentropic entanglement stable under NMP. Transfer of negentropic entanglement would be in question.
- 2. Could the non-local excitations of cyclotron Bose-Einstein condensates by large \hbar photon give rise to the negentropically entangled states? Excitation of cyclotron BE condensate requires energy so that metabolic energy is required. ATP could provide this energy. Cyclotron energy

quantum is given by $E_c = \hbar q B/m$, q and m are charged and mass of the boson. As already found, the energy of boson is sum of two contributions: energy $E_n \propto n^2$ associated with free longitudinal motion and magnetic energy $E_{c,n} \propto n + 1/2$. Longitudinal excitations could be assigned to the generation of Becker currents. This proposal would integrate metabolism, negentropy generation, and quantum like behavior of ELF em fields in living matter to single picture.

- 3. Could it be that ATP instead of being a carrier of negentropic entanglement as suggested earlier - only provides the metabolic energy quantum transformed to cyclotron energy quantum or longitudinal energy quantum when negentropic entanglement is generated by exciting the cyclotron BE condensate? Or could ATP carry both metabolic energy and negentropic entanglement and both of them are transferred to the magnetic flux tube in ATP \rightarrow ADP process?
 - (a) Cyclotron energies are quite too small for this to make sense for the ordinary value of Planck constant. The nominal value of the metabolic energy quantum is $E_0 = 0.5$ eV which by $E_0 = h_0 f_0$ corresponds to frequency $f_0 = 5 \times 10^{13}$ Hz in near infrared. The value of electron's cyclotron frequency in the endogenous magnetic field $B_{end} = .2 \times 10^{-4}$ Tesla postulated to explain the effects of ELF em fields on vertebrate brain is $f_{c,e} \simeq 6 \times 10^5$ Hz. If metabolic energy quantum is to excite cyclotron state $(n \to n+1)$, one must have $E_c = E_0$.

Even for electron E_c is much below E_0 small for $B = B_{end}$ and $\hbar = \hbar_0$. One can however scale both B from B_{end} and \hbar from \hbar_0 . Requiring $E_c(\hbar, B) = E_0$ and using $E_c = hf$ gives $f_{ce}/f_0 = r_1 r$, $r_1 = \frac{B}{B_{end}}$ and $r = \frac{\hbar}{\hbar_0}$, where \hbar_0 denotes the standard value of Planck constant. This gives $r_1 r \simeq (5/6) \times 10^8$.

(b) There are many ways to achieve the desired upwards scaling of cyclotron energies. Magnetic flux quantization gives further constraints. One could require that magnetic flux is quantized, and that for $\hbar = \hbar_0$ the flux quantum has radius of order L(151) (1 nm, cell membrane thickness) corresponding to the thickness of a flux tube assignable to single DNA nucleotide.

The radius of flux quantum corresponds to the magnetic length $r_B = \sqrt{\hbar q}B$. In the scaling $B_{end} \rightarrow 1$ Tesla $(r_1 = 2.5 \times 10^4)$, magnetic length scales as $r_B \simeq 2.5 \ \mu m \rightarrow 11$ nm. From the condition $r_1r = (5/6) \times 10^8$ one has for the scaling of Planck constant $r \sim 3.3 \times 10^3$. The scaling of the flux tubes length of L(151) would give flux tube length of order $3 \times 10 \ \mu m$, which corresponds to cell size so that a flux tube connecting DNA and cell membrane could be in question. Note that the scaling of \hbar does not affect zero point kinetic energy in the longitudinal direction since L scales as \hbar .

(c) For flux tube length L(151) and for $\hbar = \hbar_0$ the energy of the lowest longitudinal excitation is same order of magnitude as metabolic energy quantum so that the excitation of longitudinal states could be in key role in the generation of Becker's currents. There is evidence about non-local excitations of electrons in photosynthesis, [I34], which suggests that the longitudinal energy excitation could indeed play the role of fundamental metabolic energy quantum transferred to the energy of high energy phosphate bond of ATP. This interpretation leaves open the structure of high energy phosphate bond and there is no absolute need to assign zero point kinetic energy with it.

Longitudinal energies are negligible, one must require flux tube length to be considerably longer than L(151) for the ordinary value of \hbar . Longitudinal energies are significant only for electron for given flux tube length. Indeed, Becker currents are known to be carried by electrons.

(d) If one allows ionic Bose Einstein condensates the value of Planck constant must be scaled up by the mass ratio m_I/m_e , where m_I and m_e are the masses of ion and electron. For proton this would give scaling ratio $r = 2^{11}$ and one would end up with the hierarchy of Planck constants coming as powers of 2^{11} suggests years ago. What is remarkable that in cyclotron degrees of freedom also protons and ions can play a signification role: the quantal effects of ELF em fields on vertebrate brain suggest that this is the case. 4. What happens if one has just electrons rather than Cooper pairs? In both transversal and longitudinal degrees of freedom one would have the analog of Fermi sphere with electron states filled up to some maximum values integers characterizing cyclotron energy and longitudinal momentum. Transitions induce also now negentropic entanglement. For cyclotron states the energy increment would be E_c so that basic metabolic energy quantum can induce the transitions. In longitudinal degrees of freedom the minimal energy increment would be $(2N + 1)E_0$, where N characterizes the populated state with maximal longitudinal momentum. This energy should be equal to the metabolic energy quantum. This can be arranged but is not so natural. Experimental work is sooner or later bound to reveal whether electrons or their Cooper pairs are in question.

The option developed above is perhaps the most elegant found hitherto: it would raise the BE condensates of electronic and ionic Cooper pairs in a special position, it would lead to an explicit proposal for what negentropic entanglement is at the level of flux tubes, and in minimal form it would require no modification of the ideas related to ATP, even the standard view about ATP can be kept. Also the original hypothesis that ATP carries metabolic energy as zero point kinetic energy makes sense and also ATP could carry negentropic entanglement.

This view suggests that electronic cyclotron BE condensates are essential also for the understanding of photosynthesis. The absorption of dark photon would generate a non-local excitation of BE condensate of electron Cooper pairs - also a negentropically entangled state. The energy gain in this process could be also interpreted as a fundamental metabolic energy quantum - the interpretation is to some degree a matter of taste- and the subsequent steps in photosynthesis would only take care of the storage of the energy transferred eventually to ATP. Also chemical storage could be storage of negentropic entanglement. The metabolic energy liberated in ATP \rightarrow ADP could be realized universally as IR dark photon absorbed by cyclotron BE condensate at magnetic flux tube so that dark photon beams would become the key actors of metabolism and negentropy generation. Note that a maximal negentropy gain is obtained if the number of Cooper pairs in the condensate is power of prime. Relatively small primes in the scale defined by the p-adic length scales assignable to elementary particles would be in question.

8.3.3 Pessimistic Generalization Of The Second Law Of Thermodynamics

The possibility of negentropic entanglement raises the question about the fate of the second law of thermodynamics. The proposal for a generalization of the second law of thermodynamics (see chapter Negentropy Maximization Principle (see http://tinyurl.com/yd3mly5m) based on the most pessimistic vision is that entropy indeed increases also when negentropic entanglement is generated in state function reduction. If the generation of negentropic entanglement is accompanied by a compensating entropic entanglement, how it is generated? Or is the maximally pessimistic generalization really necessary? Is it implied automatically in time scales longer than the characteristic time scale associated with the causal diamonds serving as the basic correlates for conscious selves. One must apply ensemble description in these time scales: does the non-determinism of quantum jump imply second law at the level of ensemble automatically. If this argument is correct, second law would cease to hold in time scales than that characterizing the relevant causal diamond (CD). based on the most pessimistic vision is that entropy indeed increases also when negentropic entanglement is generated in state function reduction. If the generation of negentropic entanglement is accompanied by a compensating entropic entanglement, how it is generated? Or is the maximally pessimistic generalization really necessary? Is it implied automatically in time scales longer than the characteristic time scale associated with the causal diamonds serving as the basic correlates for conscious selves. One must apply ensemble description in these time scales: does the non-determinism of quantum jump imply second law at the level of ensemble automatically. If this argument is correct, second law would cease to hold in time scales than that characterizing the relevant CD.

8.3.4 How To Understand Differentiation And De-Differentiation?

Differentiation and de-differentiation are fundamental processes in biology. Differentiation means specialization and more restricted gene expression and de-differentiation a reversal of this process. De-differentiation to the stem cell state takes place in healing of wounds and is induced by Becker's DC currents. Note that cancer cells are de-differentiated cells but Becker currents induce a further de-differentiation making them omnipotent.

De-differentiation and differentiation are strongly time-irreversible processes. Could differentiation and de-differentiation be seen as time reversals of each other and correspond to state function reductions at opposite boundaries of CD? De-differentiation would mean change of geometric arrow of time but basically a dissipative process would be in question.

The following argument based on purely entropic entanglement shows that this view cannot be correct.

- 1. There are two ways to see arrow of time corresponding to embedding space level and spacetime level. The arrow of geometric time alternates only at the level of embedding space at space-time level alone it does not if irreversibility of quantum dynamics has space-time correlates as quantum classical correspondence requires. Space-time surface is not able to detect its own effective folding forth and back in time in the embedding space and the internal arrow of time remains the same. CD is able to detect the embedding space arrow of time for its sub-CD: . sub-CD seems to develop in reverse direction of geometric time. Dissipation occurs always in subjective time so that second law remains true.
- 2. Suppose that it makes sense to think that CD scans given sub-CDs again and again in time direction, which corresponds to its own arrow of geometric time. Suppose for definiteness that the scale of sub-CD is 1 year. CD observes evolution of sub-CD from 1 to 2 years then from 3 to 2 years, then from 5 to 4 years. Ageing occurs on the average. System would get 2 years older in sudden steps at both boundaries. The sudden agings by 2 years are compensated by 1 year of apparent rejuvenation between state function reductions. The interpretation as dedifferentiation is not possible. For instance, return to omnipotent stem cell stage is not possible for differentiated cells.

What is lacking is the notion of negentropic entanglement. Illness is a loss of negentropic entanglement and healing its regeneration. Aging is a loss of negentropic entanglement and dedifferentiation identified as rejuvenation is regeneration of negentropic resources.

- 1. De-differentiation must involve a generation of negentropic entanglement defining the fundamental step in rejuvenation. Ageing is due to to state function reductions destroying entanglement. Negentropically entangled states can be however stable under NMP and NMP can even force the reversal of ageing.
- 2. At the level of basic metabolism generation of ATP accompanies the generation of negentropic entanglement and its transformation to ADP to its disappearance. The creation of ATP would be fundamental process of rejuvenation, and ATP could be seen as elixir of youth at the molecular level. The analogy between ATP-ADP cycle and Karma's cycle is also rather precise. This picture conforms also with the model for healing currents as a tool to generate metabolic energy, ATP, and negentropic entanglement.

8.4 Exotic Charge Transfer Between Cell Interior And Exterior As Fundamental Control Mechanism

The notions of ionic channels and pumps associated with the cell membrane are central for the standard cell biology [I118]. There are however puzzling observations challenging this dogma and suggesting that the currents between cell interior and exterior have quantum nature and are universal in the sense that they not depend on the cell membrane at all [I87, I59, I45, I127, I57]. One of the pioneers in the field has been Gilbert Ling [I87], who has devoted for more than three decades to the problem, developed ingenious experiments, and written several books about

the topic. The introduction of the book [I82]) gives an excellent layman summary about the paradoxical experimental results.

It was a pleasant surprise to find that these experimental findings give direct support for the existence of an exotic charge transfer between cell interior and exterior.

Ionic supra currents and Josephson currents or the exchange of exotic W bosons could be in question. For the first option, the experimental data led to a model for cell homeostasis as a flow equilibrium in which very small densities of super-conducting ions (also molecular ions) and ionic supercurrents at cellular and other super-conducting space-time sheets dictate the corresponding densities at the atomic space-time sheets. Z^0 super-conductivity possible for almost vacuum extremals in principle allows to generalize the model also to the control of the densities of neural atoms and molecules at atomic space-time sheets.

This control mechanism need not be the only one. Magnetic flux tubes serving as colored braid strands connecting different bio-molecules in highly selective manner and phase transitions reducing or increasing \hbar could explain the mysterious precision of bio-catalysis as how the prebiotic evolution has led to the known biology [K6]. Magnetic flux tubes could also act as Josephson junctions between widely separated structures.

8.4.1 Strange Behavior Of The Intracellular Water

The basic strange feature of cellular interior is related to its gelatinous nature and is in fact familiar for everyone. Although 80 percent of hamburger is water, it is extremely difficult to extract this water out. Ling [I59] has demonstrated this at cellular level by using a centrifuge and cells for which cell membrane is cut open: centrifugal accelerations as high as 1000 g fail to induce the separation of the intracellular water.

The assumption that cytoplasm behaves like gel explains these findings. Egg is very familiar example of gel phase so that this proposal could have been made already by the pioneers. The dipolar nature of bio-molecules and induced polarization are basis prerequisites for the formation of gels. Ling raises the cohesion between water and protein molecules caused by electric dipole forces as a fundamental principle and calls this principle association-induction hypothesis [I87]. This cohesion gives rise to liquid [F5] [D3] like structure of water implying among other things layered structures and internal electric fields orthogonal to the plane of the layers [I106, I94, I87]. For instance, cell membranes can be understood as resulting from the self-organization of liquid crystals [K28]. The fundamental importance of electret nature of biomatter was also realized by Fröhlich [J68] and led him to suggest that macroscopic quantum phases of electric dipoles might be possible. This concept, which is in central role in many theories of quantum consciousness, has not been established empirically.

8.4.2 Are Channels And Pumps Really There?

Standard neurophysiology relies strongly on the concepts of what might be called hydro-electrochemistry. The development of the theory has occurred through gradual improvements saving the existing theory.

The development began from the basic observation that cells are stable gelatinous entities not mixing with the surrounding water. This led to the hypothesis that cell membrane takes care that the contents of the cell do not mix with the cell exterior. It was however soon found that cell membrane allows some ions to flow through. The interaction between theory and experiment led gradually to the notions of ion channel and ion pump, which are still central for the standard paradigm of the cell [I118]. Note that also "electric pump" taking care that membrane potential is preserved, is needed.

These notions developed gradually during the period when cell was seen as a bag containing water and a mixture of various biochemicals. If cell biology would have started to develop during the latter half of this century and after the discovery of DNA, cell as a computer metaphor might have led to a quite different conceptualization for what happens in the vicinity of the cell membrane. Also the notion of liquid crystals [D3] would have probably led to different ideas about how homeostasis between cell interior and exterior is realized [I106, I94, I87].

For me it was quite a surprise to find that pump-channel paradigm is not at all so wellestablished as I had believed as an innocent and ignorant outsider. The first chapter of the book "Cells, Gels and the Engines of Life" of Gerald Pollack [I82] provides a summary about the experimental paradoxes (the interested reader can find the first chapter of this book from web).

The standard theoretical picture about cell is based on the observation that cell exterior and interior are in a relative non-equilibrium. The measured concentrations of various atomic ions and organic molecules are in general different in the interior and exterior and cell membrane seems to behave like a semi-permeable membrane. There is also a very strong electric field over the cell membrane. In standard approach, which emerged around 1940, one can understand the situation by assuming that there are cell membrane pumps pumping ions from cell interior to exterior or vice versa and channels through which the ions can leak back. Quite a many candidates for proteins which seem to function like pump and channel proteins have been identified: even a pump protein for water [I82] ! This does not however prove that pumping and channelling is the main function of these proteins on the case of basic biological ions or that they have anything to do with how ionic and molecular concentrations in the interior and exterior of the cell are determined. It could quite well be that in the case of basic ions pump and channel proteins are receptors involved with the transfer of information rather than charges and only effectively act as pumps and channels.

There are several serious objections of principle against the vision of cell as a bag of water containing a mixture of chemicals. Even worse, the hypothesis seems to be in conflict with experimental data.

Selectivity problem

Cell membrane is extremely selective and this leads to an inflation in the complexity of channels and pumps. The problem might be christened as a dog-door problem: the door for dog allows also cat go through it. Channels cannot be simple sieves: it is known that channels which let some ions through do not let much smaller ions through. There must be more complicated criteria than geometric size for whether the channel lets the ion go through. Quite generally, channels must be highly selective and this seems to require complicated information processing to decide which ion goes through and which not. As a consequence, the models for channels inflate in their complexity.

The only reasonable way to circumvent the problem is to assume that there is kind of binary coding of various chemical compounds but it is difficult to see how this could be achieved in the framework of the standard chemistry. The notion of fractional atom proposed in [K49] to give rise to the emergence of symbols at the level of biochemistry could however allow this kind of coding. Channels and pumps (or whatever these structures actually are) could be also generated by self-organization process when needed.

Inflation in the number of pumps and channels

Channels and pumps for atomic ions and channels and pumps for an astronomical number of organic molecules are needed. The first question is where to put all those channels and pumps? Of course, one could think that pumps and channels are constructed by the cell only when they are needed. But how does the cell know when a new pump is needed if the cell as never met the molecule in question: for instance, antibiotic or curare molecule?

To realize how weird the picture based on channels and pumps is, it is useful to imagine a hotel in which there is a door for every possible client letting only that client through but no one else. This strange hotel would have separate door for every five point five milliard humans. Alternatively, the building would be in a continual state of renovation, new doors being built and old being blocked.

There is however an TGD based objection against this slightly arrogant argument. In TGD framework cell is a self-organizing structure and it might be that there is some mechanism which forces the cell to produce these pumps and channels by self-organization. Perhaps the basic characteristic of quantum control in many-sheeted space-time is that it somehow forces this kind of miracles to occur.

Why pumping does not stop when metabolism stops?

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 [I87] by exposing cell to a coctail of metabolic poisons and depriving it from oxygen: this should stop the metabolic activities of the cell and stop also the pumping. Rather remarkably, nothing happened to the concentration gradients! Presumably this is the case also for the membrane potential so that also 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.

How it is possible that ionic currents through silicon rubber membrane are similar to those through cell membrane?

A crucial verification of the channel concept was thought to come in the experiment of Neher and Sakmann [I128] (which led to a Nobel prize). The ingenious experimental arrangement was following. A patch of membrane is sucked from the cell and remains stuck on the micropipet orifice. A steady voltage is applied over the patch of the membrane and the resulting current is measured. It was found that the current consists of discrete pulses in consistency with the assumption that a genuine quantum level current is in question. The observation was taken as a direct evidence for the postulate that the ionic currents through the cell membrane flow through ionic channels.

The later experiments of Fred Sachs [I127] however yielded a complete surprise. Sachs found that when the patch of the cell membrane was replaced by a patch of silicon rubber, the discrete currents did not disappear: they remained essentially indistinguishable from cell membrane currents! Even more surprisingly, the silicon rubber membrane showed ion-selectivity features, which were essentially same as those of the cell membrane! Also the currents through synthetic polymer filters [I57] were found to have essentially similar properties: as if ion selectivity, reversal potential, and ionic gating would not depend at all on the structure of the membrane and were more or less universal properties. Also experiments with pure lipid-layer membranes [I45] containing no channel proteins demonstrated that the basic features – including step conductance changes, flickering, ion selectivity, and in-activation– characterized also cell membranes containing no ionic channels.

The in-escapable conclusion forced by these results seems to be that the existing 60-year old paradigm is somehow wrong. Ionic currents and the their properties seem to be universal and depend only on very weakly on the properties of the membrane. This conclusion need not apply to the currents of polar molecules for which genetically coded pump and channel proteins certainly exists. Neither does it imply that pumps and channels could not be used to achieve a more efficient transfer of ions. Pump - and channel proteins seem to be a well-established notion and TGD approach suggests that they serve as Josephson junctions.

This however requires a generalization of the ordinary thermodynamical approach to cell membrane by starting from zero energy ontology and replacing Boltzmann weight with the complex square roots. Chemical potentials giving dominant part to the change of energy as it goes through cell membrane is replaced with the difference of cyclotron energy which is in visible and UV range from the condition that dark EEG photons have energies of bio-photons [K48]. One ends up with a generalization of Josephson junction: the generalized Josephson energy includes besides Coulombic energy difference also the cyclotron energy difference. Dark cyclotron contribution raises the energy scale of 0.05-.1 eV associated with cell membrane to 0.5-10 eVs and one can understand the nominal value.5 eV of metabolic energy currency.

8.4.3 Cytoplasm As Gel

The solution to the above described anomalies proposed by Pollack is that cytoplasm is gel phase [I82]. Pollack describes in detail various aspects of cytoplasm as a gel phase and here only short summary can be given.

1. Cytoplasm can be regarded as a network consisting of cross-linked negatively charged proteins. Water is condensed around the proteins to form structured water. If protein is hydrophilic, water self-organizes around it as a multilayered structure: the number of molecular layers can as high as 600 and the thickness of the layered structure is a considerable fraction of micrometer. If the protein is hydrophobic, water forms another structured phase known as clathrate water: in this case the number of hydrogen bonds between water atoms is large. These phases can be regarded as intermediate between ice and water. Also ordinary ions have this kind of layered structure around them. Chemical cross-links tend to be stable with heat, pH, and solvent composition whereas physical cross-links formed by intermolecular interactions are sensitive to environmental interactions and are of special interest from the point of view of phase transitions.

- 2. Pollack proposes that the formation of polymers takes place in an environment containing layered water for the simple reason that monomers cannot diffuse to the layered water so that the probability of association with the end of the growing polymer increases.
- 3. Cell interior is populated by micro-tubules, various filamentary structures, and the so called micro-trabecular matrix. Micro-trabecular network divides cell into a compartments in such a manner that the typical distance between two proteins in water is about 5 nm: this corresponds to the p-adic length scale L(149), the thickness of the lipid layer of cell membrane. This is probably not an accident and the micro-trabecular network might be closely involved with the highly folded network of intracellular membranes. There would be a layer of thickness of about 6 water molecules per given protein surface so that a dominating portion of intracellular water could be structured.
- 4. The layered water has several tell-tale signatures that have been observed in gels. It freezes at much lower temperature than ordinary water; various relaxation times are shorter since the energy transfer to the water lattice occurs faster than to non-structure water; the diffusion rates of particles into the structured water are much slower than to ordinary water by entropy argument; a simple geometric argument tells that the larger the size of the hydrated ion the lower the diffusion rate; strong gradients of ionic concentrations can form in gel phase as has been observed.

The identification of the cytoplasm as a gel has profound implications for the standard views about cell.

- 1. The original motivation for postulating semipermeable cell membrane, channels, and pumps was the need to hinder the diffusion of various ions between cell interior and exterior taking place if cytoplasm is ordinary water into which molecules are dissolved. If cytoplasm is in gel phase, cell membrane need not perform pumping and channeling anymore except perhaps in situations involving the formation of a local sol phase. This raises the question about the proper functions of the cell membrane.
- 2. It is possible to drill to cell membrane holes with size of order 1 μ m without an appreciable effect on the functioning of the cell and also show that these holes remain as such for long periods of time [I82]. It is also possible to splice cells into pieces continuing to function for days. That K^+ flux through cell membrane does not change when lipids are partially removed. These findings force to ask whether the assumption about the continuity of the cell membrane might be too strong [I82]. Electron micrographs however demonstrate the presence of the bi-layered structure. What is intriguing that this structure is seen even in the absence of lipid layers. In TGD framework this paradoxical finding might be understood in terms of a presence of space-time sheets corresponding to p-adic length scales L(k), k = 149, 151 as vacuum structures predicted also by TGD inspired model of high T_c super-conductivity [K26].
- 3. There is also the strange finding that water flux through cell membrane is much higher than the flux through isolate lipid bi-layer as if some unidentified channels were present. In TGD framework this might be seen as an evidence for the presence of (wormhole) magnetic flux tubes as carriers of water molecules.
- 4. The fundamental assumptions about ionic equilibrium must be reconsidered, and the Hodkin-Huxley model for the generation of nerve pulse becomes more or less obsolete. Indeed, it has been found that action potentials can be generated even in absence of Na^+ and K^+ ions playing a key role in Hodkin-Huxley model. Rather remarkably, the high concentration of K^+ ions and low concentration of Na_+ ions in cytoplasm could be understood on basis

of gel property only. Also new view about cell (note membrane-!) potential emerges. The standard paradigm states that the resting potential is over the cell membrane. Potentials of same order of magnitude have been however seen in de-membraned cells (50 mV in slight excess of action potential and critical potential), colloidal suspensions, and gels which suggest that larger part of cell than mere cell membrane is involved with the generation of the action potential and one should thus speak of cell potential instead of membrane potential.

- 5. Pollack suggests that the phase transitions of the gel phase make possible to realize various functions at molecular and cellular level and represents empirical evidence for the phase transition like aspects assigned to these functions including sensitivity to various factors such as pH, temperature, chemical environment, electromagnetic fields, mechanical forces, etc... and the threshold behavior [I82]. Also the responses are typical for phase transitions in that they involve dramatic changes in volume, shape, di-electric constant, etc.. With these motivations Pollack discusses phase transition based models for contraction, motility, secretion, transport or molecules, organized flow of particles during cell division, cell locomotion, contraction of muscle, generation of action potentials, etc.. For instance, the transport of bio-molecules along micro-tubule could involve propagating gel-sol-gel phase transition meaning also propagating melting of the layered water around micro-tubule.
- 6. Divalent ions, such as Mg^{+2} and Ca^{+2} can act as cross links between negatively charged proteins binding them to form networks. Monovalent ions cannot do this. Peripheral cytoskeleton is this kind of network consisting of micro-tubules and actin molecules cross-linked - according to Pollack- by Ca^{+2} ions. On the other hand, it is known that Mg^{+2} (Ca^{+2}) ions dominate in the cell interior (exterior) and that the presence of Ca^{+2} ions in the cell exterior is crucial the for generation of nerve pulse. The influx of Na^+ ions having higher affinity to proteins can induce a phase transition to sol-like phase. Pollack suggests a model of nerve pulse based on this mechanism of gel-sol phase transition for peripheral cytoskeleton: this model does not actually explain why Ca^{+2} ions in the exterior of axon are necessary.

8.4.4 TGD Based Vision Inspired By The Findings

The vision about dark matter and the model of nerve pulse formulated in terms of Josephson currents brings an additional perspective to the role of pumps and channels and allows to achieve harmony with the standard views about their role.

- 1. In long length scales visible matter forms roughly 5 per cent of the total amount of matter. In TGD Universe the dark matter would correspond to matter with large Planck constant including dark variants of ordinary elementary particles. In living matter situation could be the same and visible matter could form only a small part of the living matter. Dark matter would be however visible in the sense that it would interact with visible matter via classical electromagnetic fields and photon exchanges with photons suffering Planck constant changing phase transition. Hence one can consider the possibility that most of the biologically important ions and perhaps even molecules reside at the magnetic flux quanta in large \hbar phase.
- 2. Bosonic ions could form Bose-Einstein condensates at the flux tubes in which case supra currents flowing without any dissipation would be possible. The model for high T_c superconductivity suggests that only electronic and protonic super-conductivity are possible at room temperature. If so, Cooper pairs of fermionic ions are excluded. New nuclear physics predicted by TGD could however come in rescue here. The TGD based model for atomic nucleus assumes that nuclei are strings of nucleons connected by color bonds having quark and antiquark at their ends. Also charged color bonds are possible and this means the existence of nuclei with anomalous charge. This makes possible bosonic variants of fermionic ions with different mass number and it would be interesting to check whether biological important ions like Na^+, Cl^- , and K^+ might actually correspond to this kind of exotic ions.

This leads to the following TGD inspired vision about cell as a gel.

- 1. DNA as TQC hypothesis and cell membrane as sensory receptor provide possible candidates for the actual functions of the cell membrane and ionic channels and pumps could act as kind of receptors. That standard physics is able to describe gel phase is of course a mere belief and (wormhole) magnetic flux tubes connecting various molecules (DNA, RNA, amino-acids, biologically important ions) would be "new physics" cross-links could explain the strong correlations between distant molecules of the gel phase.
- 2. Dark ionic currents are quantal currents. If the dark ions flow along magnetic or wormhole magnetic flux tubes connecting cell interior and exterior, their currents through cell membrane would be same as through an artificial membrane.
- 3. Pumps and channels could serve the role of sensory receptors by allowing to take samples about chemical environment. One cannot exclude the possibility that proteins act as pumps and channels in sol phase if magnetic flux tubes are absent in this phase since also in TGD Universe homeostasis and its control at the level of visible matter in sol phase might requires them. The metabolic energy needed for this purpose would be however dramatically smaller and a reliable estimate for this would allow an estimate of the portion of dark matter in living systems.
- 4. 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 rachet 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.
- 5. 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 [I82]. If wormhole magnetic flux are taken are taken as a basic prerequisite of life, one must ask whether these "artificial proteins" represent artificial life.
- 6. The fact that cytoskeleton rather than only cell membrane is involved with the generation of action potential conforms with the idea that nerve pulse propagating along axon involves also axonal micro-tubules and that Josephson currents between axon and micro-tubules are involved in the process.
- 7. Di-valent ions $(Ca^{+2}$ ions according to Pollack) serve as cross links in the peripheral cytoskeleton. The influx of monovalent ions from the exterior of axon induces gel-sol phase transition replacing di-valent ions with monovalent ions. One can consider two models.
 - (a) The minimal assumption is that this phase transition is induced \hbar increasing phase transition the flow of the monovalent ions like Na^+ from the cell exterior along the magnetic flux tubes connecting axonal interior and interior. Suppose that in the original situation the flux tubes end to axonal membrane (this is not the only possibility, they could also end to Ca^{+2} ions). The flux tubes extending to the axonal exterior could result by \hbar increasing phase transition increasing the length of the flux tubes connecting peripheral cytoskeleton to the axonal membrane so that they extend to the exterior of axon. This option is rather elegant since gel-sol phase transition itself can be understood

in terms of "standard chemistry". In this model the very slow diffusion rate of the ions to gel phase would have explanation in terms of new physics involving dark matter and (wormhole) magnetic flux tubes.

- (b) One can consider also an option in which divalent ions such as Ca^{+2} or Mg^{+2} are connected by two flux tubes to amino-acids of two negatively charged proteins whereas monovalent biological ions like Na^+ would have single flux tube of this kind and could not act as cross links. In the phase transitions removing the cross links the replacement of divalent ion with two monovalent positively charged ions would take place. If one believes in standard chemistry, Na^+ ions would flow in automatically. First the increase of Planck constant would induce the lengthening of the magnetic flux tubes and thus the expansion of the gel phase making possible the influx of monovalent ions. If Na^+ ions are dark, flux tubes connecting peripheral cytoskeleton to the axonal exterior are required and the mechanism of option i) is also needed.
- 8. The mechanisms i) and ii) could be fused to a single one. The hint comes from the presence of Ca^{+2} ions in the exterior of axon is necessary for the generation of action potential. The simplest possibility is that the flux tubes connecting proteins to intracellular Ca^{+2} cross links in gel phase connects them after the length increasing phase transition to extracellular Ca^{+2} ions and Na^+ ions flow along these flux tubes.
- 9. The increase of the Planck constant would induce the expansion of the peripheral cytoskeleton making possible the inflow of Na^+ ions, and divalent ions binding negatively charged actin molecules to a network would be replaced with inflowing Na^+ ions. After this a reverse phase transition would occur. Both phase transitions could be induced by a quantal control signal (Josephson current) inducing quantum criticality and a change of Planck constant.
- 10. A propagating Ca^{+2} wave inducing the gel-sol-gel phase transition of peripheral cytoskeleton would accompany nerve pulse. Quite generally, Ca^{+2} waves are known to play a fundamental role in living matter as kind of biological rhythms. Irrespective of whether one believes option a) or b), this might relate to the cross-linking by flux tubes and gel-sol-gel phase transitions induce by phase transitions increasing Planck constant temporarily. The velocities and oscillation periods of Ca^{+2} waves vary in an extremely wide range: this can be understood if the flux tubes involved correspond to a very wide spectrum of Planck constant.

Besides basic ions cell membrane is non-permeable to various polar molecules such as the basic building bricks of DNA and amino-acids. The safest assumption is that genetically coded pump and channel proteins make possible the transfer. One must of course consider the possibility that channels and pumps are used to make the transfer of basic ions more effective. Taking this into account, the proposed vision does not differ so radically from the standard one as one might think first and only the model for nerve pulse generation must be modified radically.

To sum up, the strange discoveries about the behavior of cell membrane provide direct experimental evidence for the presence of dark matter in living systems, for the prediction that it interacts with ordinary matter via classical electromagnetic fields, and for the assumption that it does not dissipate appreciably and could therefore have large value of \hbar and form macroscopic quantum phases.

8.5 Quantum Model For The Direct Currents Of Becker

Robert Becker [J17] proposed on basis of his experimental work that living matter behaves as a semiconductor in a wide range of length scales ranging from brain scale to the scale of entire body. Direct currents flowing only in preferred direction would be essential for the functioning of living manner in this framework.

One of the basic ideas of TGD inspired theory of living matter is that various currents, even ionic currents, are quantal currents. The first possibility is that they are Josephson currents associated with Josephson junctions but already this assumption more or less implies also quantal versions of direct currents. TGD inspired model for nerve pulse assumes that ionic currents through the cell membrane are quantal currents. If they are Josephson currents, the situation is automatically stationary and dissipation is small as various anomalies suggest. One can criticize this assumption since the Compton length of ions for the ordinary value of Planck constant is so small that magnetic flux tubes carrying the current through the membrane look rather long in this length scale. Therefore either Planck constant should be rather large or one should have a non-ohmic quantum counterpart of a direct current in the case of ions and perhaps also protons in the case of neuronal membrane: electronic and perhaps also protonic currents could be still Josephson currents. This would conform with the low dissipation rate.

In the following the results related to laser induced healing, acupuncture, and DC currents are discussed first. The obvious question is whether these direct currents are actually supracurrents and whether they could be universal in living matter. A TGD inspired model for quantal direct currents is proposed and its possible implications for the model of nerve pulse are discussed.

Whether the model for quantum direct currents is consistent with the proposed vacuum extremal property of the cell membrane remains an open question but both options explain the special role of Ca^{++} currents and current of Na^+ Cooper pairs in the generation of nerve pulse as in would take place in TGD Universe. In fact, it is not clear what one exactly means with the vacuum extremal property of cell membrane. Many-sheeted space-time (see Fig. http://tgdtheory.fi/appfigures/manysheeted.jpg or Fig. 9 in the appendix of this book) allows to consider space-time sheets which can be both almost vacuum extremals and far from vacuum extremals. Also space-time sheets for which Planck constant is so large that both electronic and protonic Josephson currents become possible. Various pumps and channels could actually correspond to magnetic flux tubes along which various ionic supra currents are possible in same length scale leads to the hierarchy of Planck constants coming approximately as powers of $m_p/m_e \simeq 2^{11}$ proposed originally as a general truth. Radiation at Josephson frequency serves as a signature for Josephson currents.

In the following a TGD inspired quantum model for the direct currents of Becker as direct quantum currents is developed and shown to be consistent with what is known about nerve pulse generation.

8.5.1 Connection Between Laser Induced Healing, Acupuncture, And Association Of DC Currents With The Healing Of Wounds

The findings of Robert Becker (the book "The Body Electric: Electromagnetism and the Foundation of Life" by Becker and Selden, which can be found from web (see http://tinyurl.com/ y8rbgebw) [J17], meant a breakthrough in the development of bioelectromagnetics. One aspect of bioelectromagnetic phenomena was the discovery of Becker that DC currents and voltages play a pivotal role in various regeneration processes. Why this is the case is still poorly understood and Becker's book is a treasure trove for anyone ready to challenge existing dogmas. The general vision guiding Becker can be summarized by a citation from the introduction of the book.

Growth effects include the alteration of bone growth by electromagnetic energy, the restoration of partial limb regeneration in mammals by small direct currents, the inhibition of growth of implanted tumors by currents and fields, the effect upon cephalocaudal axis development in the regenerating flatworm in a polarity-dependent fashion by applied direct currents, and the production of morphological alterations in embryonic development by manipulation of the electrochemical species present in the environment. This partial list illustrates the great variety of known bioelectromagnetic phenomena.

The reported biological effects involve basic functions of living material that are under remarkably precise control by mechanisms which have, to date, escaped description in terms of biochemistry. This suggests that bioelectromagnetic phenomena are fundamental attributes of living things, ones that must have been present in the first living things. The traditional approach to biogenesis postulates that life began in an aqueous environment, with the development of complex molecules and their subsequent sequestration from the environment by membranous structures. The solid-state approach proposes an origin in complex crystalline structures that possess such properties as semiconductivity, photoconductivity, and piezoelectricity. All of the reported effects of electromagnetic forces seem to lend support to the latter hypothesis.

Observations relating to CNS

The following more quantitative findings, many of them due to Becker, are of special interest as one tries to understand the role of DC currents in TGD framework.

- 1. CNS and the rest of perineural tissue (tissue surrounding neurons including also glial cells) form a dipole-like structure with neural system in positive potential and perineural tissue in negative potential. There is also an electric field along the neuron in the direction of nerve pulse propagation (dendrites correspond to and axon to +) (note that motor nerves and sensory nerves form a closed loop). Also microtubules within axon carry electric field and these fields are probably closely related by the many-sheeted variants of Gauss's and Faraday's laws implying that voltages along two different space-time sheets in contact at two points are the same in a static situation.
- 2. A longitudinal potential along front to back in the brain with the frontal lobes in negative potential with respect to occipital lobes and with a magnitude of few mV was discovered. The strength of the electric field correlates with the level of consciousness. As the potential becomes weaker and changes sign, consciousness is lost. Libet and Gerard observed traveling waves of potentials across the cortical layers (with speeds of about 6 m/s: TGD inspired model of nerve pulse predicts this kind of waves [K103]). Propagating potentials were also discovered in glial cells. The interpretation was in terms of electrical currents.
- 3. It was found that brain injury generated positive polarization so that the neurons ceased to function in an area much larger than the area of injury. Negative shifts of neuronal potentials were associated with incoming sensory stimuli and motor activity whereas sleep was associated with a positive shift. Very small voltages and currents could modulate the firing of neurons without affecting the resting potential. The "generating" potentials in sensory receptors inducing nerve pulse were found to be graded and non-propagating and the sign of the generating potential correlated with sensory input (say increase/reduction of pressure). Standard wisdom about cell membrane has difficulties in explaining these findings.
- 4. The natural hypothesis was that these electric fields are accompanied by DC currents. There are several experimental demonstrations for this. For instance, the deflection of assumed DC currents by an external magnetic field (Hall effect) was shown to lead to a loss of consciousness.

Observations relating to regeneration

The second class of experiments used artificial electrical currents to enhance regeneration of body parts. These currents are nowadays used in clinical practice to induce healing or retard tumor growth. Note that tissue regeneration is a genuine regeneration of an entire part of the organism rather than mere simple cell replication. Salamander limb generation is one of the most studied examples. Spontaneous regeneration becomes rare at higher evolutionary levels and for humans it occurs spontaneously only in the fractures of long bones.

1. An interesting series of experiments on Planaria, a species of simple flatworm with a primitive nervous system and simple head-to-tail axis of organization, was carried out. Electrical measurements indicated a simple head-tail dipole field. The animal had remarkable regenerative powers; it could be cut transversely into a number of segments, all of which would regenerate a new total organism. The original head-tail axis was preserved in each regenerate, with that portion nearest the original head end becoming the head of the new organism. The hypothesis was that the original head-tail electrical vector persisted in the cut segments and provided the morphological information for the regenerate. The prediction was that the reversal of the electrical gradient by exposing the cut surface to an external current source of proper orientation should produce some reversal of the head-tail gradient in the regenerate. While performing the experiment it was found found that as the current levels were increased the first response was to form a head at each end of the regenerating segment. With still further increases in the current the expected reversal of the head-tail gradient did occur, indicating that the electrical gradient which naturally existed in these animals was capable of transmitting morphological information.

- 2. Tissue regeneration occurs only if some minimum amount of neural tissue is present suggesting that CNS plays a role in the process although the usual neural activity is absent. The repeated needling of the stump had positive effect on regeneration and the DC current was found to be proportional to innervation. Hence needling seems to stimulate innervation or at least inducing formation of DC currents. Something like this might occur also in the case of acupuncture.
- 3. Regeneration involves de-differentiation of cells to form a blastema from which the regenerated tissue is formed. Quite early it was learned that carcinogens induce de-differentiation of cells because of their steric properties and by making electron transfer possible and that denervation induces tumor formation. From these findings Becker concluded that the formation of blastema could be a relatively simple process analogous to tumor growth whereas the regeneration proper is a complex self-organization process during which the control by signals from CNS are necessary and possibly realized in terms of potential waves.
- 4. Regeneration is possible in salamanders but not in frogs. This motivated Becker and collaborators to compare these situations. In an amputated leg of both salamander and frog the original negative potential of approximately -1 mV was raised first to a positive value of about +10 mV. In the frog it returned smoothly to its original value without regeneration. In the salamander it returned over a period of three days to the original base line and then went to a much higher negative value around -20 mV (resting potential is around -70 mV) followed by a return to the original value once regeneration had occurred. Thus the large negative potential is necessary for the regeneration and responsible for the formation of blastema. Furthermore, artificial electron current also induced regeneration also in the case of the frog, even in the denervated situation. Thus the flow of electrons to the stump seems to be necessary for the formation of blastema and the difference between salamander and frog is that frog is not able to provide the needed electronic current although positive potential is present.
- 5. It was also learned that a so called neuroepidermal junction (NEJ) formed in the healing process of salamander stump was responsible for the regeneration in the presence of denervation. The conclusion was that the DC voltage and electronic current relevant for regeneration could be assigned the interface between CNS and tissue rather than to the entire nerve and the regeneration seemed to be a local process, perhaps a feed of metabolic energy driving self-organization. Furthermore, NEJ seemed to make possible the flow of electrons from CNS to the stump.
- 6. The red blood cells of animals other than mammals are complete and thus possess nuclei. Becker and collaborators observed that red blood cells also dedifferentiated to form blastemas. Being normally in a quiescent state, they are ideal for studying de-differentiation. It was found that the electric current acted as a trigger at the level of cell membrane inducing de-differentiation reflected as an increased amount of mRNA serving as marker of gene expression. Also pulsed magnetic field was found to trigger the de-differentiation, perhaps via induced electric field. By the way, the role of the cell membrane fits nicely with the TGD inspired view about DNA-cell membrane system as topological quantum computer with magnetic flux tubes that are assumed to connect DNA and cell membrane and serve as braid strands in TGD inspired model of DNA as topological quantum computer [K6].
- 7. The experiments of Becker and collaborators support the identification of the charge carriers of DC currents responsible for the formation of the stump's large negative potential as electrons. The test was based on the different temperature dependence of electronic and protonic conductivities. Electronic conductivity increases with temperature and protonic conductivity decreases and an increase was observed.

Gene activation by electrostatic fields?

The basic question concerns the method of activation. The discovery of chemists Guido Ebner and Guido Schuerch [J5] raises the hope that these ideas might be more than over-active imagination and their work also provides a concrete proposal for the activation mechanism. Ebner and Schuerch

studied the effect of electrostatic fields on the growth and morphogenesis of various organisms. Germ, seeds, or eggs were placed between conducting plates creating an electric field in the range.5-2 kV/m: note that the Earth's electric field is in the range .1 - 4 kV/m and of the same order of magnitude.

The outcome was rather surprising and in the year 1989 their employer Ciba Geigy (now Novartis) applied for a patent "Method of enhanced fish breeding" [J5] for what is called Ciba Geigy effect. The researchers describe how fishes (trouts) develop and grow much better, if their eggs have been conditioned in an electrostatic field. The researchers also reported [J5] that the morphology of the fishes was altered to what seems to represent an ancient evolutionary form: this was not mentioned in the patent.

The chemists founded their own Institute of Pharmaceutical Research near Basel, where Guido Ebner applied for another very detailed patent, which was never granted. In the patent he describes the effect of electrostatic fields on several life forms (cress, wheat, corn, fern, microorganisms, bacteria) in their early stage of development. A clear change in the morphogenesis was observed. For instance, in one example fern had all sort of leaves in single plant apparently providing a series of snapshots about the evolution of the plant. The evolutionary age of the first leaf appeared to be about 300 million years whereas the last grown-up leaf looked close to its recent form.

If one takes these finding seriously, one must consider the possibility that the exposure to an electrostatic field can activate passive genes and change the gene expression so that older morphologies are expressed. The activation of not yet existing morphologies is probably more difficult since strong consistency conditions must be satisfied (activation of program requires activation of a proper hardware). This would suggest that genome is a kind of archive also containing also older genomes even potential genomes or that topological quantum computer programs [K6] determine the morphology to a certain extent and that external conditions such as electric fields determine the self-organization patterns characterizing these programs.

It is known that the developing embryo has an electric field along the head-tail axis and that this field plays an important role in the control of growth. These fields are much weaker than the fields used in the experiment. p-Adic length scale hierarchy however predicts an entire hierarchy of electric fields and living matter is indeed known to be full of electret structures. The strength of the electric field in some p-adic length scale related to DNA might somehow serve as the selector of the evolutionary age. The recapitulation of phylogeny during ontogeny could mean a gradual shift of the activated part of both genome and "memone" (as as menetic analog of genome: for a proposal of memetic code see [K61]), perhaps assignable to topological quantum computer programs realized as braidings, and be controlled by the gradually evolving electric field strength.

The finding that led Ebner to his discovery was that it was possible to "wake up" ancient bacteria by an exposure to an electrostatic field. The interpretation would be in terms of loading of metabolic batteries. This would also suggest that in the case of primitive life forms like bacteria the electric field of the Earth has served as metabolic energy source whereas in higher life forms endogenous electric fields have taken the role of Earth's electric field.

A TGD based model for the situation

On the basis of these observations one can try to develop a unified view about the effects of laser light, acupuncture, and DC currents. It is perhaps appropriate to start with the following - somewhat leading - questions inspired by a strong background prejudice that the healing process - with control signals from CNS included - utilises the loading of many-sheeted metabolic batteries by supra currents as a basic mechanism.

The first series questions, observations, and ideas relates to the connection of DC currents with metabolism and ordinary biochemistry. The hierarchy of Planck constant is expected to be involved somehow.

1. How the DC currents relate to metabolism and ordinary biochemistry? For what purpose they are needed? The crucial point is that the energy of order 1 meV gained by electron in the electric field is much below the metabolic energy quantum and also thermal energy so that the interpretation in terms of metabolic energy quantum does not look promising. This forces to consider the possibility that the basic role of electric field is to drive electrons to where they are needed, say wounded part of tissue in positive potential and thus attracting electrons. Electrons are indeed needed by the electron transport cycle appearing in both photosynthesis and cell respiration since the transport cycle induces leakage of electrons due to the formation of ROS (reactive oxygen species) such as O_2^- . The purpose of electronic Becker currents would be therefore the re-establishment of metabolism.

The change of the sign of the Becker potential to positive induce a loss of electrons and reduced metabolism. This could explain why consciousness is lost when the sign of Becker potential is changed or electrons are deviated by Hall effect. Wound damages the connections of the tissue to the organism and the transfer of electrons compensating for leaked electrons is prevented since Becker potential changes sign. The regeneration induced by an artificial Becker potential of correct sign would induce healing by re-establishing the electron feed.

The crucial question concerns the role of electrons. It seems that in all situations electron flow to the damaged tissue induces healing. Why electrons generating negative potential should help in healing? The first input is TGD model [K98] [L36] for the findings of Pollack [L36] involves the connection of dark matter hierarchy $h_{eff} = n \times h$ with negentropic entanglement characterized by density matrix reducing to $n \times n$ unit matrix for entanglement matrix proportional to a unitary matrix. In infinite-dimensional case the divisor is infinite unless one uses von Neumann's hyperfinite factor of type II₁ for which the normalization factor can be taken to be unity: in the case of quantum groups this corresponds to using quantum trace instead of the ordinary one. A further input is the observation that the gravitational Planck constant h_{gr} explaining planetary Bohr quantization rules can be equal to h_{eff} in living matter for microscopic systems like elementary particles, atoms, and ions, even molecules [K122, K101].

- 1. Pollack's findings about fourth phase of water formed when external energy feed induces formation of negatively charged exclusion zones of water obeying stoichiometry $H_{1.5}O$ with 1/4: th of protons going to the complement of exclusion zone. Something similar might happen also now.
- 2. In TGD framework this process is explained as a formation dark phase of protons at the magnetic flux tubes associated with the exclusion zone with dark protons realizing genetic code so that one obtains what might be regarded as primitive primordial life form.
- 3. There is evidence for a huge anomalous gravimagnetic Thomson field in rotating super conductors. Thomson field is proportional to square of Planck constant h_{eff} and TGD explanation is that large h_{gr} phase is formed at gravitational flux tubes. The assumption $h_{gr} = h_{eff}$ in elementary particle and atomic scales is possible and is consistent with the hypothesis that bio-photons in visible and UV energy range correspond to decay products of dark EEG photons.
- 4. \hbar_{gr} can be generalized to $\hbar_{em} = -Z_1 Z_2 e^2 / v_0$: v_0 would be typical rotational velocity in a system with opposite charges Z_1 and Z_2 . Exclusion zone would be good example. For ATP v_0 would be rotational velocity of ATP. For exclusion zone v_0 could be rotational velocity of Cooper pairs in magnetic field associated with flux tubes or walls or rotational velocity of magnetic body. $Z_2 = -Z_1$ is natural assumption by charge neutrality.
- 5. In this framework the feed of electrons would increase the value of h_{eff} by increasing the negative charge associated with the analog of exclusion zone accompanying the wound and induce also a flow of dark protons to the magnetic flux tubes associated with the magnetic body of the analog of exclusion zone.
- 6. The DC currents would be needed because the damage of the tissue means that the $\hbar_{eff} = \hbar_{em} = Z^2 e^2/v_0$ is reduced for a pair formed by damaged system and its complement. Healing would be essentially attempt to increase h_{eff} to its original value. The parameter Z^2 is reduced and must be increased to its original value and perhaps even to a higher value since the larger ger the value of h_{eff} is, the richer the negentropic resources of system are. The transfer of electrons to the system analogous to exclusion zone induces transfer of dark protons to the magnetic flux quanta of the magnetic body of the system. Recall that dark proton strings at flux tubes could be analogs of dark nuclei and that the model for dark

nucleons allows to identify nucleon states as counterparts of DNA, RNA, amino-acids and even tRNA. This leads to a model of prebiotic lifeforms [K62].

- 7. ATP synthase transforming ADP to ATP involves rotating shaft and one can ask whether the velocity parameter v_0 appearing in the expression for \hbar_{em} equals to the rotation speed of the shaft. This predicts that the value of \hbar_{em} to be same order as \hbar_{eff} and \hbar_{gr} for Earth-electron system assuming that v_0 corresponds to the rotation velocity at the surface of Earth. The assumption $h_{eff} = h_{gr} = h_{em}$ makes it possible for the gravitational and em flux tubes to reconnect.
- 8. The original guess was that electrons to provide energy giving rise to the formation of ATP in cell respiration and photosynthesis. Electrons themselves receive their energy either from the oxidation of molecules or from solar photons. This model is consistent with the model above since electron transport chain is crucial for cell transpiration and needs both electrons and dark protons located at the dark flux tubes associated with the exclusion zones. Dark protons would flow through the ATP synthase attached to mitochodrial membrane and liberate dark cyclotron energy if the value of the magnetic fields associated with the flux tube is different for the interior and exterior portions of the flux tube [K48, K97].

The experimental support for the role of bio-photons in living matter is accumulating and a natural question concerns their role in metabolism. In TGD framework dark photons with large value of \hbar_{eff} with energy of visible photon can transform to ordinary photons of same energy with some - presumably rather small - probability, and would be interpreted as bio-photons. Could dark photons take the role of solar photons and provide in some situations energy to the electrons in the electron transport cycle? This would mean a non-conventional non-local mechanism of metabolism. The effects of laser light on tissue suggest that laser light indeed takes the role of solar light and feed energy to the electron transport cycle transforming it to the energy of high energy phosphate bond of ATP. A more detailed TGD inspired view about what might happen is discussed in [K69].

One can consider also the possibility that quantum credit card mechanism (remote metabolism) could be at work in some the situations when chemical metabolic energy sources are absent. Damaged tissue might define this kind of exceptional situation. This brings in mind the strange ability of plants suffering under-nutrition to attract insects responsible for their pollination observed by Callahan, who has also reported that plants and insects communicate using infrared light which according to his findings serves as a sensor input in insect olfaction [I32]: also in this case quantum credit card mechanism building magnetic flux tube bridges guiding the insects to the plant might be at work. The electrons which have gained 1 meV energy during travel along pairs formed by MEs and parallel magnetic flux tubes (meridians), could send negative energy dark photons with energy of order -.5 eV to gain same positive energy allowing to get over the semiconductor junction after they have arrived to the damaged tissue. These negative energy photons would be absorbed by a metabolic energy store (ATP in mitochondria transforming to ADP) in the healthy part of the organism.

 $h_{eff} = h_{em}$ implies that the spectrum of bio-photons originating from dark cyclotron photons is universal having no dependence on ion mass and in visible and UV range, which is also the range for molecular excitation energies. Dark cyclotron photons decaying to bio-photons would therefore allow magnetic body to control biochemistry by resonant absorption inducing transitions of molecules.

The original model for the charging of the metabolic batteries and for effective semiconductor junction assumed that the electrons of supra current are transferred to smaller space-time sheets.

1. For ground state electrons this requires energy which is at least the difference of zero point kinetic energies of electron at the two space-time sheets. This energy should be of the order of fundamental metabolic energy quantum of about 5 eV.

For Cooper pairs of electrons the sheet should correspond to p-adic length scale of order $L_e(k_e = 149) = 10$ nm, the thickness of lipid layer of cell membrane. For single proton corresponding scale would be $L_e(k_p = 139) \simeq 2^{-12}L_e(151)$ from $m_p/2m_e \simeq 2^{10}$ and $E_{0,p}/E_{0,2e} = (2m_e/m_p) \times (L_e(k_e)/L_e(k_p))^2 = (2m_e/m_p) \times 2^{k_e-k_p} \sim 1$.

This suggests that electron Cooper pair is kicked to a smaller space-time sheet assignable to a mitochondrial lipid layer having $k_e = 149$. The larger space-time sheet could be that of cell membrane with k = 151. For protons the zero point kinetic energies at these space-time sheets are by a factor $2m_e/m_p$ lower and of the order of .5 meV. This happens to be of the same order of magnitude as the energy gained by proton or electron in the Becker potential. May be this is not an accident.

There is also a second intriguing quantitative co-incidence. In the absence of an action potential, acetylcholine vesicles spontaneously leak into the synaptic junction and cause very small de-polarizations in the postsynaptic membrane known as miniature end plate potentials (see http://tinyurl.com/y98zhxzh) (mEPSP) of magnitude .5 mV. These potentials are too small to generate action potential but together they can sum up to the needed action potential. Maybe the interpretation in terms of proton kicked to lipid layer space-time sheet might make sense.

2. The re-charging mechanism should relate directly to ADP→ ATP process occurring during electronic transport cycle in mitochondrial membrane. The connection with metabolism forces to ask how the formation of high energy phosphate bond in the addition of phosphate to ADP relates to the transfer of electrons to smaller space-time sheet. Somehow the energy of electrons must go to the formation of this bond: perhaps the dropping of electron back to larger space-time sheet transfers the energy to the high energy phosphate bond.

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.

- 3. The transfer of particles between space-time sheets with different p-adic length scales is not the only one that one can consider, and recently a more elegant mechanism has emerged [K69]. If the particles are free, a phase transition in which the p-adic prime of the space-time sheet containing particles decreases adiabatically increases the scale of kinetic energy but leaves particle quantum numbers unchanged. If the same happens for charge particles at magnetic flux tubes, similar increase of cyclotron energy scale takes place since magnetic field strength increase to conserve magnetic flux. The predictions are in good approximation the same as for the original model. If the phase transition reducing p-adic length scale is accompanied by a compensating increase of Planck constant, the size scale of space-time sheet remains unaffected but metabolic batteries are loaded. The reversal of this phase transition liberates metabolic energy. What is important that metabolic energy and negentropic entanglement (measured in terms of the value of Planck constant) are closely correlated for this mechanism. The loading/liberation of energy is also a quantum coherent process.
- 4. Acupuncture and the application of DC current are known to induce the generation of endorphins. Do endorphins contribute to well-being by reducing the pain? In TGD framework the deeper level interpretation of metabolism is as a provider of negentropic entanglement in turn giving rise to well-being. Are endorphins kind of negentropy packets or just conscious signals about the improved situation?

Second series of questions, observations, and ideas relates to the meridians, acu points, and "chi".

1. A permanent potential difference of same sign between head and tail could mean an accumulation of positive and negative charges to the ends of the of the system if only electron currents are present. If both electron and proton currents with opposite directions are present, there is no accumulation of charge but there is an accumulation of protons and electrons. Probably there exists a pumping mechanism forcing the electrons (and possibly also protons) to move against the potential gradient from the tail back to the head. This however requires metabolic energy and the simplest source of this energy would be just the energy of electrons otherwise used to generate ATP. If so, the leakage would not be an unavoidable dissipative effect but a way to avoid charge accumulation.

If the pumping mechanism is not at work, this situation cannot continue for ever and the sign of the potential difference must eventually change and induce loss of consciousness. The simplest possibility is that the potential difference changes sign rhythmically. A natural question is whether the sleep-awake rhythm is unavoidable and corresponds to the oscillatory behavior of the head-to-tail voltage.

"Chi" would correspond electrons or their Cooper pairs in this picture. Abnormal chi flow (reduced flow, flow in wrong direction, accumulation of chi) would cause various problems including also insomnia in which too much electron charge tends to accumulate.

3. What is the nature of acupuncture meridians, what kind of currents flow along them, and why are they not directly observed? The most natural identification in TGD Universe would be in terms of magnetic flux tubes accompanied by parallel massless extremals (MEs) making possible also the propagation of dark photons used for control purposes and perhaps even in metabolism as already discussed. Dark currents along pairs of MEs and magnetic flux tubes are ideal for the transfoer of particles and energy.

If the length of the superconducting "wire" is long in the scale defined by the appropriate quantum scale proportional to \hbar , the classical picture makes sense and charge carriers can be said to accelerate and gain energy ZeV. For large values of \hbar_{eff} an oscillating Josephson current would be in question. Since Becker currents are associated with CNS, it would be natural to associate the meridians with neural pathways although this assignment is not necessary. Magnetic flux tube system defined kind of magnetic circulation which could serve as a template for the neural pathways. The transfer of energy with minimal dissipation would explain why a semiconductor like property is needed and why acupuncture points have a high conductivity value.

4. What about acu-points? Acu points are known to be in negative potential normally. This suggests that the density of electrons or their Cooper pairs at them is higher than elsewhere in the meridian. Could they server as kind of electron stores providing electrons to their environment to compensate for losses caused by ROS. This would make possible higher metabolic activity in presence of nutrient molecules since the rate for the electron transform cycle should be proportional to the density of energizable electrons, "chi".

When the potential of the acu-point is reduced or become positive, under-nutrition follows. This should relate to various symptoms like pain at acupuncture points. Acupuncture needle as an electronic conductor would develop a charge distribution with a concentration of electrons to the acu-point, and would re-establish the metabolic activity. Pain would be signature of lack of negentropic entanglement (see Fig. http://tgdtheory.fi/appfigures/cat.jpg or Fig. ?? in the appendix of this book) and positive/negative coloring of emotions and sensations would quite generally correlate with the amount of negentropic entanglement.

 Nanna Goldman *et al* have provided empirical evidence (see http://tinyurl.com/4to42pc) [I55] for the expectation that the healing effect of the acupuncture involves metabolism (see the popular article in Sciencedaily (see http://tinyurl.com/3734uub) [I33]).

The group has found that adenosine is essential for the pain killing effects of acupuncture. For mice with a normal adenosine level acupuncture reduced dis-comfort by two-thirds. In special "adenosine receptor knock-out mice" acupuncture had no effect. When adenosine was turned on in the tissues, the discomfort was reduced even in the absence of acupuncture. During and after an acupuncture treatment, the level of adenosin in tissues near the needles was 24 times higher than before the treatment. In the abstract of the article it is stated that it is known for long time that acupuncture generates signals which induce brain to generate natural pain killing endorphins but that also adenosine acts as a natural pain killer.

Adenosine is the basic building block of AXP, X=M, D, T (adenosin-X-phosphate, X=mono, di, tri). Therefore the findings suggest that the flow of electrons from the needle to acu point loads metabolic batteries by providing electrons to electron transport cycle needed to generate ATP. Adenosine could be partially generated as decay products of AXPs. Tissue itself could

increase adenosine concentration to make possible its transformation to AXP utilizing electric field energy. From the popular article one cannot conclude whether the authors propose a connection with metabolism. The results are consistent with the assumption that the AXPs generated from adenosin accompany negentropic entanglement. This can occur in the scale of entire body and meridians could also make possible direct signalling with brain.

How can understand the semiconducting character of Becker's DC currents?

1. Becker assigns to the system involved with DC currents an effective semiconductor property. Could the effective semiconductor property be due the fact that the transfer of charge carriers to a smaller space-time sheet by first accelerating them in electric field is analogous to the transfer of electrons between conduction bands in semiconductor junction? If so, semiconductor property would be a direct signature of the realization of the metabolic energy quanta as zero point kinetic energies. For metabolic energy quantum of order .5 eV this however makes sense only if the electrons transferred to the smaller space-time sheet have energy slightly below the minimum energy for the transfer to the smaller space-time sheet in absence of the Becker potential. The situation would be critical and 1 mV voltage could serve as a kind of control knob.

One can imagine the analog of this mechanism also when the external energy feed corresponds to a phase transition reducing p-adic length scale and increasing Planck constant so that the size of the space-time sheet remains unaffected. Again 1 mV voltage would have the role of control knob.

- 2. Supra currents flowing along magnetic flux tubes would make possible dissipation-free loading of metabolic energy batteries. This even when oscillating Josephson currents are in question since the transformation to ohmic currents in semiconductor junction makes possible energy transfer only during second half of oscillation period. Could this be a universal mechanism applying to various stages of the regeneration process? In quantal situation the metabolic energy quanta have very precise values as indeed required.
- 3. The findings of Becker provide support for electronic DC currents. The Cooper pairs of electrons are indeed the best candidates for the carriers of supra current by their small mass. In the minimal situation the currents defined by leaked electrons moving against potential gradient (utilising the energy used otherwise to generate ATP) could compensate the Becker currents and give rise to closed current loops without charge accumulation. If the electronic DC currents observed by Becker are much stronger than needed to compensate for the local electron leakage, a larger metabolically driven return current is needed to guarantee local charge neutrality. These currents seem to be assignable to CNS: maybe the two electron currents could be associated with sensory and motor pathways. An interesting question whether sympathetic-parasympathetic dichotomy also relates to electron currents in opposite directions.
- 4. Could also dark protonic and even ionic DC currents be present and running along their own flux tubes and perhaps defining cyclotron Bose-Einstein condensates? How large the scale of flux tubes can be: could it be much larger than that of biological body (by simple argument magnetic body should have layers with even size scale of Earth). What is the possible connection with cell respiration? When single ATP is generated, three protons are are pumped through the mitochondrial membrane utilising the energy liberated in electron transport cycle. This does not however require protonic currents in longer scales.
- 5. In regeneration process NEJs are formed. They could consist of pairs of MEs and magnetic flux tube mediating the electronic DC current during blastema generation and regeneration proper during which also control signals from CNS would be present. Since NEJs seems to resemble cell membranes in some respects, the ideas inspired by the model of cell membrane and DNA as TQC can be used. The model for nerve pulse and the model for DNA as topological quantum computer suggest that dark ionic currents flowing along magnetic flux tubes characterised by a large value of the effective Planck constant are involved with both meridians and NEJs. Magnetic flux tubes can act as DC current wires or Josephson junctions

generating oscillatory supra currents of ions and electrons. Also for large values of the effective Planck constant meridians look short in the relevant dark length scale and could act as Josephson junctions carrying oscillatory Josephson currents.

One can raise also questions about the relationship between DC currents and de-differentiation.

- 1. Could cell de-differentiation be caused by the presence of Becker's DC current? Also acupuncture is known to induce de-differentiation. Could the mere ability to charge metabolic energy batteries provided by electron feed induce de-differentiation, which manifests as an increased genetic expression? Can one see differentiation as an eliminative process forced by the reduction of the electron feed and inducing a selective reduction of gene expression? If this were the case, de-differentiation could be induced by a feed of surplus electrons to the system using either external electron current or additional electric field. Local electron density would correlate negatively with the degree of differentiation.
- 2. In this framework it might be possible to understand the claimed effects of external electric fields on the development of plants and fishes. In this case rejuvenation means return to the earlier evolutionary stages. Maybe ontogeny-recapitulates-phylogeny principle might allow to understand this if genome in some sense contains archive about earlier stages of evolution. This archive might be virtual and realised by an epigenetic mechanism selecting different patterns of gene expression using the same genome.

If this is the case, the density of electrons or their Cooper pairs - "chi" - possessed by the cell would serve as a measure for the biological age of the cell and the meridian system feeding "chi" would serve as a rejuvenating agent with respect to gene expression. The average density of dark electrons would serve as a measure for the age of cell: the larger the density the higher the metabolic activity and the lower the biological age.

8.5.2 Quantum Model For Effective Semiconductor Property

Becker [J17] summarizes his findings by stating that living matter is an effective semiconductor. There are pairs of structures in positive and negative potential in various scales and the current between the plates of this effective capacitor flows when above some minimum potential difference. The current flows from positive to negative pole and could be an electron current. Also proton current in the opposite direction can be considered but the electron current is experimentally favored. For instance consciousness is lost when a magnetic field is used to deflect the current.

In TGD framework natural carriers of these currents would be magnetic flux tubes also carrying electric fields. A very simple deformation of the embedding of a constant longitudinal magnetic field also gives longitudinal electric field. With a slight generalization one obtains helical electric and magnetic fields. A crucial difference is that these currents would be quantal rather than ohmic currents even in the length scale of the biological body and even longer scales assignable to the magnetic body.

The following argument allows us to understand the physical situation.

- 1. A precise everyday analogy is vertical motion in the gravitational field of the Earth between surface and some target at given height h. If the kinetic energy is high enough, the particle reaches the target. If not, the particle falls back. In the quantum case one expects that the latter situation corresponds to a very small probability amplitude at the target (tunnelling to classically forbidden kinematic region).
- 2. Now the electric field replaces the gravitational field. Suppose that the classical electric force experienced by the particle is towards the capacitor plate taking the role of the surface of Earth. Below critical field strength the charged particle cannot reach the target classically and quantum mechanically this occurs only by tunnelling with vanishingly small probability.
- 3. Particles with opposite value of charge experience a force which accelerates them and classically they certainly reach the second plate. What happens in a quantum situation? It seems that this situation is essentially identical with the first one: one has linear potential in finite interval and wave functions are localized in this range. One can equivalently regard these states as localized near the second capacitor plate.

4. A good analogy is provided by atoms: classically the electron would end down at the nucleus but quantization prevents this. One can imagine also now stationary solutions for which the electric currents for individual charges vanish at the plates although classically there would be a current in another direction. Also quantum mechanically non-vanishing conserved current is possible: all depends on boundary conditions.

Basic model

Consider now the situation at more quantitative level.

1. One can assign complex order parameters Ψ_k to various Bose-Einstein condensates of supra phases and obey Schrödinger equation

$$i\partial_t \Psi_k = \left(-\frac{\hbar^2}{2m_k}\partial_z^2 + q_k Ez\right)\Psi_k \quad . \tag{8.5.1}$$

Here it is assumed that the situation is effectively one-dimensional. E is the value of constant electric field.

2. The Schrödinger equation becomes non-linear, when one expresses the electric field in terms of the total surface charge density associated with the plates of effective capacitor. In absence of external electric field it is natural to assume that the net surface charge densities σ at the plates are of opposite sign so that the electric field inside the capacitor is proportional to

$$\sigma = E = \sum \sigma_i = \sum_i q_i \overline{\Psi}_i \Psi_i \quad . \tag{8.5.2}$$

This gives rise to a non-linear term completely analogous to that in non-linear Schrödinger equation. A more general situation corresponds to a situation in which the region interval [a, b] bounded by capacitor plates a and b belongs to a flux longer tube like structure [A, B]: $[a, b] \subset [A, B]$. In this case one has

$$E_{tot} = E + E_0 . (8.5.3)$$

This option is needed to explain the observations of Becker that the local strengthening of electric field increases the electron current: this would be the case in the model to be discussed if this field has a direct opposite to the background field E_0 . One could also interpret E as quantized part of the electric field and E_0 as classical contribution.

3. The electric currents are given by

$$j_k = \frac{i\hbar q_k}{2m_k} \overline{\Psi}_k \partial_z^{\leftrightarrow} \Psi_k \quad . \tag{8.5.4}$$

In stationary situation the net current must vanish:

$$\sum_{k} j_{k} = 0 . (8.5.5)$$

A stronger condition is that individual currents vanish at the plates:

$$j_k = 0$$
 . (8.5.6)

It must be emphasized that this condition does not make sense classically.

Explicit form of Schrödinger equation

Consider now the explicit form of Schrödinger equation in a given electric field.

1. The equation is easy to solve by writing the solution ansatz in polar form (the index k labelling the charge particle species will be dropped for notational convenience).

$$\Psi = R(aexp(iU) + bexp(-iU))exp(-iE_nt)$$
(8.5.7)

For real solutions current vanishes identically and this is something which is not possible classically. It is convenient to restrict the consideration to stationary solutions, which are energy eigen states with energy value E_n and express the general solution in terms of these.

2. The Schrödinger equation reduces with the change of variable

$$z \rightarrow \frac{(z-z_0)}{z_1} \equiv x$$
,
 $z_0 = \frac{E_n}{qE}$, $z_1 = (\frac{\hbar^2}{2mqE})^{1/3}$. (8.5.8)

 to

$$(\partial_x^2 + x)\Psi = 0 . (8.5.9)$$

The range $[0, z_0]$ for z is mapped to the range $[-z_0/z_1, 0]$. z_0/z_1 has positive sign as is easy to verify. The value range of x is therefore negative irrespective of the sign of qE. This is the differential equation for Airy functions (see http://tinyurl.com/6b8yh7) [B1]. Airy functions are encountered in WKB approximation obtained by linearing the potential function: $V(x) = ax + b + O(x^2)$.

The change of variable leads automatically to solutions restricted near the plate where the situation is completely analogous to that in the gravitational field of the Earth. For stationary solutions a test charge in a given background field would be localized near the capacitor plate with opposite sign of charge. A strong background field could be created by charges which do not correspond to the ionic charges defining ionic currents. Electrons and protons could define this field possibly associated with flux tubes considerably longer than the distance between capacitor plates.

3. Using the polar representation $\Psi = Rexp(iU)$ Schrödinger equation reduces to two equations

$$\left[(\partial_x^2 - U_x^2 + x)R \right] \cos(U) + \left[U_{xx} + 2\partial_x R \partial_x U \right] \sin(U) = 0 , \left[(\partial_x^2 - U_x^2 + x)R \right] \sin(U) - \left[U_{xx} - 2\partial_x R \partial_x U \right] \cos(U) = 0 .$$

$$(8.5.10)$$

Note that both (R, U) and (R, -U) represent solutions for given value of energy so that the solution can be chosen to be proportional to cos(U) or sin(U). The electric current j is conserved and equal to the current at x = 0 and given by

$$j = \frac{\hbar}{2m} \frac{U_x}{z_1} R^2 , \quad z_1 = (\frac{\hbar}{2mqE})^{1/3} .$$
 (8.5.11)

The current vanishes if either U_z is zero or if the solution is of form $\Psi = Rsin(U)$.

Semiclassical treatment

In semiclassical approximation the potential is regarded as varying so slowly that it can be regarded as a constant. In this situation one can write the solution of form Rexp(iU) as

$$\Psi = R_0 exp\left(\frac{i}{\hbar} \int_0^z \sqrt{2m} \sqrt{E - qEz} dz\right) = R_0 exp\left(i \int_0^x x^{1/2} dx\right) \quad . \tag{8.5.12}$$

The plate at which the initial values are given can be chosen so that the electric force is analogous to gravitation at the surface of Earth. This requires only to replace the coordinate z with a new one, vanishing at the plate in question - and gives to the energies a positive shift $E_0 = qE_0h$.

1. The semiclassical treatment of the equation leads to Bohr rules

$$\frac{\oint p_z dz}{\hbar} = \frac{2}{\hbar} \int_0^h p_z dz = n \quad . \tag{8.5.13}$$

This gives

$$\frac{\oint p_z dz}{\hbar} = \frac{2\sqrt{2m}}{\hbar} \int_0^h \sqrt{E_n - qEz} dz = 2 \int_0^{x_0} x^{1/2} = \frac{4}{3} x_0^{3/2} = n \quad . \tag{8.5.14}$$

Note that the turning point for classical orbit corresponds to $z_{max} = E_n/qE$.

2. One obtains

$$E_n = \frac{1}{2} \left(\frac{nqE\hbar^2}{r\sqrt{m}}\right)^{2/3} , \quad r = \int_0^1 (1-u)^{1/2} du = \frac{2}{3} . \quad (8.5.15)$$

The value of z_{max} is

$$z_{max} = \frac{E_n}{qE} = \frac{n^{2/3}}{2r^{2/3}} \left(\frac{\hbar^2}{qEm}\right)^{1/3} .$$
(8.5.16)

3. The approximation $R = R_0 = constant$ can make sense only if the position of the second plate is below z_{max} . This is possible if the value of n is large enough $(n^{2/3} \text{ proportionality})$, if the mass m of the charged particle is small enough $(m^{-1/3} \text{ proportionality})$ raising the electron and also the proton to a special position, or if the strength of the electric field is small enough $(E^{-1/3} \text{ proportionality})$. The value z_{max} is proportional to $\hbar^{2/3}$ so that a phase transition increasing Planck constant can induce current flow.

Possible quantum biological applications

The proposed model for quantum currents could provide quantum explanation for the effective semiconductor property of Becker's DC currents.

1. The original situation would be stationary with no currents flowing. The application of an external electric field in the correct direction would reduce the voltage below the critical value and currents would start to flow. This is consistent with Becker's findings if there is a background electric field E_0 with direction opposite to that of the applied field has a direction opposite to E_0 so that the field strength experienced by charged particles is reduced and it is easier for them to reach the second plate.

2. Becker's DC currents appear in several scales. They are assigned with the pairs formed by CNS and perineural tissue (this includes also glia cells) and by frontal and occipital lobes. Acupuncture could involve the generation of a DC supra current. The mechanism would be essential in the healing. Also the mechanism generating qualia could involve generation of supra currents and dielectric breakdown for them. The role of the magnetic flux tubes in TGD inspired biology suggests that the mechanism could be universal. If this were the case one might even speak about a Golden Road to the understanding of living matter at the basic level.

Even the generation of nerve pulse [K103] might be understood in terms of this mechanism. One can argue that neurons have a higher evolutionary level than the system pairs to which only electron currents or electron and proton currents can be assigned. This is because the value of the effective Planck constant is higher for the magnetic flux tubes carrying the quantal ionic currents.

- 1. For Bose-Einstein condensate the simplest choice is n = 1 at both plates. The energy eigenvalues would naturally differ by the shift $E_0 = qE_0h$ at the two plates for a given particle type. Under these assumptions the current can flow appreciably only if the voltage is below the minimum value. This is certainly a surprising conclusion but brings in mind what happens in the case of neuronal membrane. Indeed, hyper-polarization has a stabilizing - something difficult to understand classically but natural quantum mechanically.
- 2. The reduction of membrane potential slightly below the resting potential generates nerve pulse. Also a phase transition increasing the value of the effective Planck constant might give rise to quantal direct currents and generate flow of ionic currents giving rise to nerve pulse. Stationary solutions are located near either capacitor plate. What comes to mind is that the nerve pulse involves a temporary change of the capacitor plate with this property.
- 3. If the electron and proton currents flow as direct currents, one encounters a problem. Nerve pulse should begin with direct electronic currents and be followed by direct protonic currents and only later ions should enter the game if at all. The existing model for nerve pulse however assumes that at least electrons flow as oscillating Josephson currents rather than direct quantal currents. This is quite possible and makes sense if the cell membrane thickness is small that is comparable to electron Compton length as assumed in large \hbar model for the nerve pulse. This assumption might be necessary also for proton and would make sense if the Planck constant for protonic flux tubes is large enough. For ions the Compton length would be much smaller than the thickness of cell membrane and direct currents would be natural.

If the value of the effective Planck constant is the same for biologically important ions, direct quantum currents would be generated in definite order since in $h < z_{max}$ one has $z_{max} \propto m^{-1/3} \propto A^{-1/3}$. The lightest ions would start to flow first.

- (a) Nerve pulses canbe generated by voltage gated channels for potassium and calcium. Voltage gated channels would correspond to magnetic flux tubes carrying electric field. For voltage gated channels Na⁺ ions with atomic weight A = 23 and nuclear charge Z = 11 start to flow first, then K^+ ions with atomic weight A = 39 and Z = 19 follow. This conforms with the prediction that the lightest ions flow first. The nerve pulse duration is of the order of 1 millisecond at the most.
- (b) Nerve pulses can be also generated by voltage gated Ca^{+2} channels. In this case the duration can be 100 ms and even longer. Ca has A = 40 and Z = 20. The proper parameter is $x = r^2/qA$, $r = \hbar/\hbar_0$. One has

$$\frac{x(Ca^{++})}{x(Na^{+})} = \left(\frac{r(Ca^{++})}{r(Na^{+})}\right)^2 \times \frac{23}{2 \times 40} \quad . \tag{8.5.17}$$

 $r^2(Ca_{++}) \sim 2r^2(Na_+)$ would allow to compensate for the increased weight and charge of Ca_{++} ions.

4. The objection is that Na^+ and K^+ are not bosons and therefore cannot form Bose-Einstein condensates. The first possibility is that one has Cooper pairs of these ions. This would imply

$$\frac{x(Ca^{++})}{x(2Na^{+})} = \left(\frac{r(Ca^{++})}{r(Na^{+})}\right)^2 \times \frac{23}{20}$$

 Ca^{++} and Na^{+} pair would be in very similar position for a given value of Planck constant. This is a highly satisfactory prediction. Another manner to circumvent the problem is more science fictive and assumes that the Na^{+} ions are exotic nuclei behaving chemically as Na^{+} but having one charged color bond between nucleons [L3].

It remains to be seen whether this model is consistent with the model of cell membrane as almost vacuum extremal or whether the vacuum extremal based model could be modified by treating ionic currents as direct currents. In the vacuum extremal model classical Z^0 gauge potential is present and would give a contribution to the counterpart of Schrödinger equation. The ratio $x(Ca^{++})/x(2Na^{+})$ for the parameter $x = r^2/q(A - Z)A$ (em charge q is replaced with neutron number in good approximation) equals to 1.38 and is not therefore very far from unity.

The many-sheetedness of space-time is expected to play a key role and one should precisely specify which sheets are almost vacuum extremals and which sheets are far from vacuum extremals. One expects that magnetic flux tubes are far from vacuum extremals and if voltage gated ionic channels are magnetic flux tubes, the proposed model might be consistent with the model of cell membrane as almost vacuum extremal.

The effects of ELF em fields on vertebrate brain

The effects of ELF em fields on vertebrate brain occur both in frequency and amplitude windows. Frequency windows can be understood if the effect occur at cyclotron frequencies and correspond to absorption of large \hbar photons. A finite variation width for the strength of magnetic field gives rise to a frequency window. The observed quantal character of these effects occurring at harmonics of fundamental frequencies leads to the idea about cyclotron Bose-Einstein condensates as macroscopic quantum phases. The above considerations support the assumption that fermionic ions form Cooper pairs.

I have tried to understand also the amplitude windows but with no convincing results. The above model for the quantum currents however suggests a new approach to the problem. Since ELF em fields are in question they can be practically constant in the time scale of the dynamics involved. Suppose that the massless extremal representing ELF em field is orthogonal to the flux tube so that the ions flowing along flux tube experience an electric force parallel to flux tube. What would happen that the ions at the flux tube would topologically condensed at both the flux tube and massless extremal simultaneously and experience the sum of two forces.

This situation is very much analogous to that defined by magnetic flux tube with longitudinal electric field and also now quantum currents could set on. Suppose that semiconductor property means that ions must gain large enough energy in the electric field so that they can leak to a smaller space-time sheet and gain one metabolic quantum characterized by the p-adic length scale in question. If the electric field is above the critical value, the quantum current does not however reach the second capacitor plate as already found: classically this is of course very weird. If the electric field is too weak, the energy gain is too small to allow the transfer of ions to smaller space-time sheet and no effect takes place. Hence one would have an amplitude window.

The amplitude window occur in widely separate ranges 1-10 V/m and around 10^{-7} V/m. Of course, also other ranges might be possible. Fractality and the notion of magnetic body suggests a possible explanation for the widely different frequency ranges. Both p-adic length scale hypothesis and the hierarchy of Planck constants suggest that some basic structures associated with the cell membrane have fractal counterparts in a wide length scale range and correspond to binary structures. Magnetic flux tubes carrying quantal DC currents of Becker would be the most natural candidate in this respect since these currents appear in several length scales inside organism. Also the counterparts of lipid layers of cell membrane could be involved. If so, one must include to the hierarchy of amplitude windows also fields in the range corresponding to the cell membrane resting

potential of about 6×10^6 V/m. This is of course only a rough order of magnitude estimate since perturbations of these field are in order.

Fractality motivates some guess for voltage and electric field.

1. The voltage along the flux tube could be invariant under the scaling of Planck constant. The interpretation could be that the charges at the ends of the linear structure generate an electric flux running along the structure do not depend on the length L of the structure so that the electric field along linear structure behaves as $1/L \propto 1/h_{eff}$ as a function of the length scale $L \propto h_{eff}$ so that voltage between the ends does not depend on the length of the structure. This would give rise to a universal amplitude window for voltage rather than potential. The cell membrane electric field of 6×10^6 V/m would correspond to the field 6 mV/m. This kind of voltages could be associated with Becker's DC currents and the order of magnitude would be around few mV.

Note that if the electric flux is like that between point charges, the scaling law $E \propto 1/h_{eff}^2$ holds true.

2. There could be also a constant electric field along microtubular structures due to polarization - most naturally tubulin polarization. This field strength serves as a candidate for a universal amplitude window for electric field.

The idea that the direct currents of Becker run between lipid layers of cell does not conform with the hypothesis about generalized Josephson currents between them. There are electric fields along microtubules and one could wonder whether the DC voltages of Becker could relate to the voltages between the ends of linear structures formed by axonal and dendritic microtubules connected to each other by MAPs - single MT can have a length up to about 1 cm. The longitudinal electric field due to the dipole moments of tubulins and confined to tubulin structure does not depend on its length L, and the electric field of 1 mV/m would correspond $10^3 \text{ V}/\mu\text{m}$, which is by order of magnitude larger than the constant longitudinal dipole electric field of order $10^2 \text{ eV}/\mu\text{m}$ generated by tubulin dipoles estimated to have strength 337 Debye in [I67] (note that MT has radius of R = 25 nm, thickness of $\Delta R = 4$ nm and length of d = 8 nm and the volume of MT fragment defined by 13 parallel tubulins is given by $V = 13 \times 2\pi R^2 \Delta R$ and that electric is E = p/V). If Becker's direct currents correspond to electric fields due to the charge difference between the ends of tubulins, one can consider the possibility that Becker's longitudinal electric fields have micro.tubular origin.

3. Electric field in the range E = 1 - 10 V/m assignable to EEG would correspond to field of $(1-10) \times 10^3$ V/µm and seems to be too large to be assigned with microscopic structures. DNA is a possible candidate since the smaller thickness of DNA would increase the dipole moment density by a factor of order 10^3 from that for MTs. The electric field of 10^{-7} eV/m seems to be associated with much larger structure than organism.

Effects of 50 Hz magnetic fields on living matter

The vision about the role of cyclotron Bose-Einstein condensates was inspired by the effects of ELF em fields on vertebrate brain. The magnetic field strength explaining the effects was about.2 Tesla, 2/5 of the nominal value for the strength of Earth's magnetic field.

There are also other experiments have demonstrated that oscillating electromagnetic fields have effects on living matter. In particle oscillatory magnetic fields with frequency of 50 Hz and with field strengths typically in the range.1-1 mT are used: these effects are summartized in [J102]. Even fields of order.14 Tesla are used.

It is interesting to look at the values of basic parameters associated with these fields.

1. For 50 Hz oscillation frequency the wave length λ is 6000 km to be compared with the radius of Earth which is 6371 km. If one takes seriously the notion of magnetic body this need not be an accident. I do not know how essential it is to have just 50 Hz frequency. The magnetic field is nearby oscillating dipole field (see http://tinyurl.com/36c4pfg) up to distances of order λ and radiation field at much longer distances. Therefore the field in question is in good approximation nearby field as fart as biological body is considered. For magnetic body the radiation field could dominate
- 2. For the endogenous magnetic field $B_{end} = .2$ Gauss cyclotron frequencies of ions are in EEG range: Ca^{++} cyclotron frequency is 15 Hz. The scaling up to r=.1-1 mT means scaling of cyclotron frequencies by a factor 5 50. For Ca^{++} this would give frequency range 75-750 Hz. For K^+ and Cl^+ ions the frequency range would be about 35-375 Hz.
- 3. The magnetic length $r = \sqrt{2/eB}$ characterizing flux tube thickness for flux quantization with minimum value of flux is for B = .05 mTesla equal to 5 μ m. For the fields in the range .1-1 mTesla it is in the range 3.5 μ m- 1.1 μ m. 2.5 μ m corresponds to p-adic length scales $L_e(k)$ associated with Gaussian Mersenne $M_{G,k} = (1+i)^k - 1$, k = 167, and Gaussian Mersenne corresponding to k = 163 would correspond to p-adic length scale .36 μ m. .14 Tesla corresponds to magnetic length of 9.4 nm rather near to cell membrane thickness of 10 nm which corresponds to p-adic length cale $L_e(151)$ assignable to Gaussian Mersenne $M_{G,151}$.

The effects of polarized light on living matter

Polarized light is known to have effects on living matter [J102]. For instance, Peter Gariaev has found that the polarized light generated by living matter sample irradiated by polarized laser light has effects on distant organism and there are even indications that genetic code might be realized in terms of radiation patterns [K149]. The quantum model for Becker currents suggest that these effects result as a modification of the voltage between the ends of magnetic flux tubes If the flux tubes are near criticality for the generation of quantal DC currents, polarized light could be utilized both communication and control purposes wheres the acceleration in the electric fields along flux tubes would serve as a provider of metabolic energy allowing to load metabolic batteries. This process could be initiated by an electromagnetic signal inducing generation of quantal currents. The same basic mechanism could be at work also in DNA transcription, replication and other similar processes.

If the polarized low frequency radiation corresponds to a massless extremal (ME) orthogonal to the flux tube such that the polarization of the radiation is parallel to the flux tube, the voltage is affected by a contribution given by $\Delta V = Ed$, d the thickness of ME. If the flux tube is near criticality to a generation of quantal currents this change of voltage could serve as a signal inducing the generation of quantal currents.

The maximal effect is obtained for the flux tubes having direction parallel to the electric polarization so that the effect is highly selective. In the case of DNA double strand the direction of flux tube changes so that the effect would be maximal on DNAs which correspond to the same angular position on the super-coil of radius of order 10 nm formed by DNA double helix. This allows to imagine signals for which temporal variation of polarization direction means scanning of DNA.

It is known that the energy of radiation can be transformed to metabolic energy. For instance, IR light for which photons have energies of order metabolic quantum has biological effects [I131]. The mechanism could be following. Suppose that the electric field of IR photon is parallel to the flux tube which carries an electric field and is near criticality for the generation of quantal DC currents. If the direction of polarization is correct, the additional contribution to electric field induces direct current and acceleration of electrons and protons and their transfer to smaller space-time sheets and therefore loading of metabolic batteries. This could also make generation of ATP possible.

Suppose that one takes seriously the model for remote replication of DNA [K149] involving flux tubes connecting identical DNA nucleotides and that the radiation propagating along them induces quantal currents along the receiving DNA inducing replication and perhaps even transcription. The direction of polarization for the emitted radiation should be parallel to the DNA strand locally and during its travel to the target the polarization should remain orthogonal to the flux tube so that one would have what might be called polarization window. Parallel translation of the polarization vector in the induced metric suggests itself.

Support for the proposed interaction mechanism of em radiation fields with flux tubes

The basic prediction of the interaction mechanism is that the effects of em field with a given frequency occur only at the second half period when the direction of electric field is "correct". This prediction might be testable. In fact, there is evidence for this interaction mechanism in the case of theta waves of EEG. The memory storage occurs only at the second half of the theta wave This is discussed from different point of view in [K6].

The place coding by phase shifts was discovered by O'Reefe and Recce [J91]. In [J113, J112]. Y. Yamaguchi describes the vision in which memory formation by so called theta phase coding is essential for the emergence of intelligence. It is known that hippocampal pyramidal cells have "place property" being activated at specific "place field" position defined by an environment consisting of recognizable objects serving as landmarks. The temporal change of the percept is accompanied by a sequence of place unit activities. The theta cells exhibit change in firing phase distributions relative to the theta rhythm and the relative phase with respect to theta phase gradually increases as the rat traverses the place field. In a cell population the temporal sequence is transformed into a phase shift sequence of firing spikes of individual cells within each theta cycle.

Thus a temporal sequence of percepts is transformed into a phase shift sequence of individual spikes of neurons within each theta cycle along linear array of neurons effectively representing time axis. Essentially a time compressed representation of the original events is created bringing in mind temporal hologram. Each event (object or activity in perceptive field) is represented by a firing of one particular neuron at time τ_n measured from the beginning of the theta cycle. τ_n is obtained by scaling down the real time value t_n of the event. Note that there is some upper bound for the total duration of memory if scaling factor is constant.

One can say that neurons in ensemble provide a representation for the external world and the location of the rodent in the external world is represented as a firing of a neuron in this landscape. Besides this also temporal scaling down by a factor about ten is carried out so that actual event is represented as much shorter copies of it. Obviously this represents temporal fractality.

This scaling down - story telling - seems to be a fundamental aspect of memory. Our memories can even abstract the entire life history to a handful of important events represented as a story lasting only few seconds. This scaling down is thought to be important not only for the representation of the contextual information but also for the memory storage in the hippocampus. Hierarchy of Planck constants and phase transitions changing Planck constant make this story building possible.

The finding of Yamaguchi and collaborators relevant in the recent context is that the gradual phase shift occurs at half theta cycle whereas firings at the other half cycle show no correlation [J113]. The proposed model for the interaction of theta waves with flux tubes could explain this naturally. The relevant neural sub-system would be critical to the generation of quantal DC current only when the direction electric field of synchronizing theta wave generated by magnetic body is correct. Hence synchronous neural activity would be induced only at second half cycle of theta wave and firing would be random during the other half cycle.

8.5.3 A Model For Remote Gene Expression Based On Becker Currents

If one accepts the notion of magnetic body as intentional agent, the basic challenge is to understand how magnetic body realizes its intents as remote mental interactions on biological body. This model must of course apply also to the more conventional remote mental interactions such as remote realization of intent.

The hypothesis is that electromagnetic and possibly also other massless classical fields assignable to so called massless extremals are in a key role. Also cyclotron frequencies characterizing magnetic bodies play a key role. The vision is that magnetic flux sheets traverse many-sheeted DNA in various scales giving rise to a hierarchy of genomes and coherent gene expression in scales of cell, organelles, organism, and even population, and species. Hierarchy of Planck constants is in an essential role in realizing this hierarchy in terms of photons with energies above the thermal energy at physiological temperature and having spectrum of wavelengths coming as multiples $\lambda = n\lambda_0, n = \hbar/\hbar_0$.

The findings of Benveniste and followers relating to water memory and homeopathy, the recent work of group led by HIV Nobelist Luc Montagnier coupling the findings with genetics and suggesting a new nanoscale realization of genetic code [L16]), the work of the group of Popp with bio-photons identified as decay produces of large \hbar photons with visible energies (in particular dark EEG photons), and the work of Peter Gariaev and collaborators supporting remote gene expression and replication discussed [K149] suggest that electromagnetic radiation is indeed involved. In the case of water memory and homeopathy the spectrum of cyclotron frequencies for the chemical

invader characterizes it and induces immune response trying to eliminate it. I have also proposed a model for how genes coding for proteins eliminating the invader could be generated almost automatically: the model is based on the predicted realization of vertebrate genetic code in terms of dark proton states [K62]. DNA would like an animal which sniffs the invaders magnetic body and automatically reacts to the smell.

The discussions with Lian Sidorov and people who have realized that new era is beginning in biology have served as a driving force in the attempts to formulate in more detail TGD inspired view about how remote mental interactions - which are basic element of the model in TGD framework - might be realized. As a matter fact, I have added to my homepage a new book summarizing briefly the recent view about quantum TGD and its applications to quantum consciousness, quantum biology, to quantum neuroscience, and to remote mental interactions with some proposals for possible tests [K129]).

To start with, suppose that in the case of biological target realization of intent in the simplest situation reduces to expression of genes. This is of course a strong limitation to the type of remote mental interactions. The challenge is to develop a model for remote realization of genetic activities like replication, and transcription. For some time ago I proposed a model with Peter Gariaev [K149] but it was still too clumsy since it required too much of information transfer between the genomes of sender and receiver. Much simpler model involving only sending of simple commands initiating genetic programs suggests itself. The following proposal tries to achieve this and involves three basic ideas.

- 1. The idea of password and addressing is familiar from ordinary computers. Collection of frequencies as password/address allows to reach tuned targets without specific targeting of the command. This is a dramatic improvement to the previous model.
- 2. Password and fractal addressing realized in terms of frequencies coupling resonantly (already in the original model: I did not however realize the implications of resonant coupling!) and the hierarchy of Planck constants to realize the hierarchical addressing. I have discussed analogous addressing based on information molecules and their receptors at the biochemical level to realize magnetic flux tube connections between sender and target inside organism (hormonal action would be very analogous to what I am proposing here).
- 3. Becker's DC currents as supra currents flowing along DNA and activated optimally when the incoming laser light has polarization parallel to DNA's local direction, activation of super currents would mean activation of the gene. This is second new element to the original model.

In the following I discuss this with more details.

The analogy with ordinary computer

Consider first the analog of remote mental interactions for ordinary computer. Computer sends a password to the other computer and after that it can use it to run programs of the other computer. Whisling to a dog is another example: extremely simple command activates arbitrary complex programs.

In the recent case electromagnetic radiation with a given frequency coupling resonantly like radio signal to a tuned radio receiver would be the simplest command activating the target. There would no need to specify the direction or distance of the target precisely since essentially mass communications would be in question: intent would be enough. Password could consist of several frequencies which must be received simultaneously by the target before it would activate and tunes to receive more frequencies representing simple commands - perhaps acting on the intronic portion of DNA and activating the genome to remote gene expression or something else such as activating DNAs of other cells by sending similar em addresses!

I have discussed topological quantum computer programs (see http://tinyurl.com/y84g3tk7) based on braiding could look like in this framework [L22]. Also here addressing but now realized as information molecule-receptor pair would play a key role.

Hierarchy of Planck constants and hierarchical addressing

Fractal hierarchy of frequencies (in Peter's experiment laser light induced generation of radiation at frequencies down to about 10 kHz) would allow to transform passwording to addressing. Very naïvely, the longest wavelengths: about 10^4 meters would reach the tuned receivers in nearly the same phase in a region of this size. One would have some subregions in tune. The shorter wavelengths would allow to pinpoint the tuned receivers inside each of these subregions and so on. This would be fractal addressing with most significant bits correspond to the longest wavelengths. Only those receivers which would be tuned to all frequencies would start to express the gene in the case of AND logic. Of course, also other Boolean functions of tuned-not tuned bits can be considered.

A good guess is that all photons correspond to the same energy of visible photon and only Planck constant varies. For ordinary value of Planck constant one would have a photon with wavelength of order size scale of single cell, and the frequencies in this range would select single gene in the genome of a particular kind of cell, say neuron within particular region of brain.

In Peter Gariaev's experiment involving 2 eV incoming red laser light the outgoing photons would have same energy but larger Planck constant so that also wavelengths would be longer and range down to at least 3×10^4 meters corresponding to radiofrequency scale of 10 kHz. What is interesting that 2 eV is 4 times the nominal value of the metabolic energy quantum of 5 eV identifiable as zero point kinetic energy of electron or proton for the p-adic length scale $L_e(151)$ corresponding to cell membrane thickness and Gaussian Mersenne $M_{151} = (1 + i)^{151} - 1$. Could it be that 2 eV could be preferred photon energy or is its use simply due to the unavailability of continuous frequency spectrum for laser light. And why the laser light induces the generation of the command inducing remote gene expression?

This picture conforms with Peter's experiment and with the reports of Benveniste and followers about the possibility of representing homeopathic remedy using very low frequency spectrum presumably cyclotron frequencies - assignable to remedy. These frequencies would be addresses for genes activating genes transcribing building bricks of biomolecules of immune response eliminating the substance from the organism. The proposal could be seen as a generalization of Benveniste's observation and realization of wave DNA proposal.

DNA supra currents and activation of genes by Becker mechanism

The third bulding brick of the model would be quantum model for Becker currents (see http: //tinyurl.com/ybnjk9bq) [L24] as supra currents or quantal DC currents: also this element is new. Assume - in accordance with the general vision - that these supra currents can flow also along the strands of many-sheeted DNA (flux sheets associated with the strand, entire hierarchy labelled by the values of \hbar). Assume also that the interaction of polarized photons addressing for genes with DNA is such that the electric fields of DNA flux tube and "massless extremal" representing laser beam superpose and charges (electrons) experience the superposition of field already present and the field of ME. If the net electric field is near criticality originally (think as analog neuronal membrane) and becomes over-critical, quantal Becker current starts to flow and the machinery responsible for gene activation is activated.

This means also the activation of metabolic machinery since the acceleration of electrons in the electric field gives them energy making possible a transfer to smaller space-time sheets where they form Cooper pair like states with negentropic entanglement. Metabolic energy corresponds to zero point kinetic energy and negentropic entanglement is relevant from the point of view of consciousness: in the case of healing understood as a regeneration of negentropic resources this aspect is especially important. This mechanism generates high energy phosphate bonds in ATP and the decay ATP \rightarrow ADP liberates the metabolic energy and destroys the negentropic entanglement possibly associated with ATP so that the second law in generalized form (see http: //tinyurl.com/yakmqhz6) [L18] allowing local generation of genuine negentropy (but assigned to information carried by entanglement defining a quantum rule) wins after all.

It could also happen that the decay of ATP generates dark photon or photons absorbed by cyclotron condensate at magnetic flux tube. The excited state is non-local single particle excitation and involves very simple negentropic entanglement between the particles of the condensate. In this case the negentropy of ATP would be transformed to the negentropy of the magnetic flux tube or even several of them if large value of Planck constant is associated with the photon. This mechanism could allow the generation of negentropic entanglement associated with attention. The storage of metabolic energy in photosynthesis could involve similar excitation of cyclotron state at the first step. The most plausible candidate is cyclotron condensate for electron Cooper pairs. Also electrons filling state up to some Fermi energy could be in question. In this case the excitations would be excitation in longitudinal degrees of freedom of the flux tube generating current.

8.5.4 DNA, Speech, Music, And Ordinary Sound

Peter Gariaev's group has made rather dramatic claims about DNA during years [I52, I53, I86, I85].

- 1. The group has proposed that the statistical distributions of nucleotides and codons in the intronic portion of DNA resemble the distribution of letters and words in the natural languages [I85]. For instance, it is proposed that Zipf law [J65] applying to natural languages applies to the distributions of codonds in the intronic portion of DNA. One can study the popularity of the words in natural languages and order them against their popularity. Zipf law states that the integer characterizing popularity is in constant proportion to the number of times it appears in given long enough text.
- 2. It has been also claimed that DNA can be reprogrammed using modulated laser light or even radio waves. I understand that reprogramming means a modified gene expression. Gariaev's group indeed proposes that the meaning of the third nucleotide (having a rather low significance in the DNA-amino-acid correspondence) in the genetic codon depends on the context giving rise to a context dependent translation to amino-acids. This is certainly a well-known fact for certain variants of the genetic code. This context dependence might make possible the re-programming. The notion of dark DNA allows to consider much more radical possibility based on the transcription of dark DNA to mRNA followed by translation to amino-acids. This could effectively replaced genes with new ones.
- 3. Also the modulation of the laser light by speech is claimed to have the re-programming effect. The broad band em wave spectrum resulting in the scattering of red laser light on DNA is reported to have rather dramatic biological effects. The long wave length part of this spectrum can be recorded and transformed to sound waves and these sound waves are claimed to have the same biological effects as the light. The proposal is that acoustic solitons propagating along DNA represent this effect on DNA.

I do not have the competence to make statements about the plausibility of these claims. TGD view about quantum biology makes also rather strong claims. The natural question is however whether a justification for the claims of Gariaev and collaborators could be found in TGD framework? In particular, can one say about possible effects of sound on DNA. One intriguing fact about sound perception is that music and speech have meaning whereas generic sounds to not. Could one say something interesting about how this meaning is generated at the level of DNA?

Basic picture

Before continuing it is good to restate the basic TGD inspired ideas about the generation of meaning.

1. The generation of the negentropic entanglement is the correlate for the experience of the meaning. In the model inspired by Becker's findings [L24], the generation of negentropic entanglement (see Fig. http://tgdtheory.fi/appfigures/cat.jpg or Fig. ?? in the appendix of this book) involves a generation of supra currents along flux tubes moving in the electric field parallel to them. This is a critical phenomenon taking place when the voltage along the flux tube is near critical value. The generation of nerve pulse near critical value of the resting potential is one example of this criticality. Becker's direct currents involved with the healing of wounds is another example.

The flow of the supra current gives rise to the acceleration of charges along the flux tubes and generation of Cooper pairs or even many-electrons systems at smaller space-time sheets in negentropically entangled state and carrying metabolic energy quantum as zero point kinetic energy. The period of negentropic entanglement gives rise to a conscious experience to which one can assign various attributes such as understanding, attention, and so on. Negentropic entanglement would measure the information contained by a rule having as instances the state pairs in the quantum superposition defining the entangled state. When the period of negentropic entanglement ceases, the metabolic energy is liberated.

- 2. Remote activation of DNA by analogs of laser beams is another essential piece of TGD inspired quantum biology [L24]. In the proposed addressing mechanism a collection of frequencies serves as a password activating intronic portions of DNA. This would take place via a resonance for the proposed interaction between photons and dark supra currents flowing along magnetic flux tubes and perhaps also along DNA strands or flux tubes parallel to them. The superposition of electric fields of photons (massless extremals) with the electric fields parallel to flux tubes (so that massless extremals serving as correlates for laser beams would traverse the flux tube in orthogonal direction).
- 3. The flux tubes, and more generally flux sheets labelled by the value of Planck constant, and along which the radiation arrives would be transversal to DNA and contain DNA strands. This kind of flux tubes and sheets also define the connections to the magnetic body, and form parts of it. A given flux sheet would naturally select the portion of DNA, which is activated by the radiation: it could be a portion of intronic part of DNA activating in turn a gene. These flux tubes and sheets could be connected to the lipids of nuclear and cell membranes also cell membranes of other cells as assumed in the model of DNA as topological quantum computer [K6]. The sheets could also give rise to a hierarchy of genomes besides genome one would have super-genome in which genomes are organelles are integrated by flux sheets to a large coherently expressed structure containing individual genomes like page of a book contains lines of text. These pages would be in turn organized to a book hyper-genome as I called it. One could have also libraries, etc... There would fractal flux quanta inside flux quanta structure.

Phonons and photons In TGD Universe

Consider next phonons and their coupling to photons in TGD Universe.

- 1. Sound waves could quite well transform to electromagnetic radiation since living matter is piezo-crystal transforming sound to radiation and vice versa. Microwave hearing represents an example of this kind transformation. This would require that photons of given energy and varying value of Planck constant couple to phonons with the same energy, Planck constant, and frequency.
- 2. Whether one can assign to phonons a non-standard value of Planck constant is not quite clear, but there seems to be no reason preventing this. If so, even photons of audible sounds would have energies above thermal threshold and have direct quantal effects on living matter if they have same Planck constant as the photons with same frequency.
- 3. Acoustic phonons represent longitudinal waves and this would require longitudinal photons. In Maxwell's electrodynamics they are not possible but in TGD framework photon is predicted to have a small mass and also longitudinal photons are possible.
- 4. For general condensed matter systems one can have also optical phonons for which the polarization is orthogonal to the wave vector and these could couple to ordinary photons. The motion of the charged particles in the electromagnetic field of massless extremal (topological light ray) would be a situation in which phonons and photons accompany each other. This would make possible the piezo-electric mechanism.

Under these assumptions the collections of audible frequencies could also represent passwords activating the intronic portion of the genome and lead to gene expression or some other activities. If one believes on the hypothesis that DNA acts like topological quantum computer based on the braid strand connections between nucleotides in the intronic portion of DNA with the lipids of the nuclear and/or cell membranes, also topological quantum computation type processes could be activated by the collections of sound frequencies [K6].

What distinguishes speech and music from sounds without meaning?

Speech and music ares very special form of sound in that they have direct meaning. The more one thinks about these facts, the more non-trivial they look. For music - say singing - the frequency of the carrier wave is piecewise constant whereas for speech it remains constant and the amplitude modulation is important. In fact, by slowing down the recorded speech, one gets the impression that carrier frequency is actually modulated like in chirp (frequency goes down and covers a range of frequencies). What is the mechanism giving to speech and music its meaning and in this manner distinguishes them from other sounds?

Besides the frequency also phase is important for both speech and music experience. Speech and reverse speech sound quite different the intensity in frequency space is same. Therefore the relative phases associated with the Fourier coefficients of various frequencies must be important. For music simple rational multiples of the fundamental define the scale. Could it be that also the frequencies relevant to the comprehension of speech correspond to these rational multiples?

Suppose that one indeed believes on the proposed vision based on the fundamental role of negentropic entanglement in generation of meaning and takes seriously the proposed mechanisms for generating it. Can one understand why music and speech differ from general sounds and what distinguishes between them?

- 1. With these assumptions suitable collections of frequencies sound wave would indeed activates the intronic portion of DNA by generating negentropic entanglement. Also other dark flux tubes than those assignable to DNA are involved. For instance, hair cells responsible for hearing of sounds around particular frequencies could involved flux tubes and utilize similar mechanism. Allowing only hair cells would define the conservative option. On the other hand, one could well claim that what happens in ear has nothing to do with the understanding of the speech and music, it could take place only at the level of neuronal nuclei.
- 2. Could the direct interaction of sound waves with magnetic flux tubes generate the experiences of speech and music? In other words, assign meaning to sounds? The criterion for sound to have an interpretation as speech or music would be that it contains the resonance frequencies needed to activate the DNA, or more generally generate dark super currents generating Cooper pairs in this manner loading metabolic energy storages. This would apply to both speech and musical sounds.
- 3. The pitch of the speech and musical sound can vary. We are aware of the key of the music piece and of modulations of the key and remember the starting key, and it is highly satisfactory to make a return to "home" defined by the original key. This would imply that the overall scale of the collection of frequencies can be varied and that the pitch of the speech defines a natural expectation value of this scale. For persons possessing so called absolute ear this scaling symmetry would be broken in a well-defined sense.
- 4. Musical scales involve frequencies coming as rational multiples of the basic frequency. Octaves - power of two multiples- of the frequency can be said to be equivalent as far musical experience is considered. One might understand the special role of rational multiples of the basic frequency if the Fourier components have same phase periodically so that the experience is invariant under discrete time translations. This requires commensurable frequencies expressible as rational multiples of the same fundamental frequency. The preferred role of p-adic primes comings as powers of two could relate to the octave phenomenon.
- 5. Are the relative phases of different Fourier components important for music experience? If one requires a periodical occurrence of maximal possible intensity (maximal constructive interference) then the relative phases must vanish at the values of time for maximal possible intensity. What seems essential that the presence of commensurate frequencies gives rise to time translation invariant sensation whereas speech consists of pulses.

Are speech and music quantum duals like position and momentum?

Frequencies are crucial for music experience. In the case of of speech the relative phases are very important as the example of reverse speech demonstrates. How a given phoneme is heard is determined to high degree by the frequency spectrum in the beginning of the phoneme (this distinguishes between consonants). Vowels are nearer to notes in vocalization. Speech consists of pulses and destructive interference between different frequencies is required to generate pulses and different pulse shapes so that phase information is important. At least the harmonics of the basic rational multiples of the fundamental are necessary for speech.

One can criticize the previous discussion in that it has been completely classical. Phase and frequency are in wave mechanics canonically conjugate variables analogous to position and momentum. Is it really possible to understand the difference between music and speech purely classically by assuming that one can assign to sound waves both frequencies and phases simultaneously - just like one assigns to a particle sharp values of both momentum and position? Or should one use either representation either in terms numbers of phonons in different modes labelled by frequencies or as coherent states of phonons with ill defined phonon numbers but well defined amplitudes? Could the coherent states serve as the analogs of classical sound waves. Speech would be as near as possible to classical sound and music would be quantal. Of course, there is a large variety of alternative choices of basis states between these two extremes as a specialist in quantum optics could tell.

Suppose that this picture is more or less correct. What could be the minimal scenario allowing to understand the differences between speech and music?

- 1. Only a subset of frequencies could activate DNA (or if one wants to be conservative, the hair cells) also in the case of speech. One could still pick up important frequencies for which the ratios are simples rational numbers as in the case of musical scale plus their harmonics If this assumption is correct, then speech from which all frequencies except for the harmonics of the simple rational multiples of the fundamental are removed, should be still be comprehensible as speech. The pitch of the speech would determine a good candidate for the fundamental frequency.
- 2. The harmonics of frequencies activating DNA would be crucial for speech. Harmonics are present also in music and their distribution allows to distinguish between different instruments and persons. The deviation of musical notes from ideal Fock states would correspond to this.
- 3. The naïve guess is that the simple rational multiples of fundamental and the possibility of having their harmonics could be reflected in the structure of intronic portions of DNA as repetitive structures of various sizes. This cannot be the case since the wavelengths of ordinary photons would be so small that the energies would be in keV range. Neither is this expected to be the case. It is magnetic flux tubes and sheets traversing the DNA which carry the radiation and the natural lengths assignable to these flux quanta should correspond to the wave lengths. The larger, the flux quantum, the lower the frequency and the larger the value of Planck constant. Harmonics of the fundamental would appear for given flux tube length naturally.

The DNA strands and flux tubes and sheets form a kind of electromagnetic music instrument with flux quanta taking the role of guitar strings and DNA strands and other structures such as lipids and possible other molecules to which flux tubes get attached taking the role of frets in guitar. This analogy suggests that for wave lengths measured in micrometers the basic frequencies correspond to the distances between "frets" defined by cell and nuclear membranes in the tissue in the scale of organism. This would relate the spectrum of resonance frequencies to the spectrum of distances between DNAs in the tissue.

For wave lengths corresponding to very large values of Planck constant giving rise to frequencies in VLF and ELF range and corresponding also to audible frequencies, the preferred wave lengths would correspond to lengths of flux quanta in Earth size scale. One should understand whether the quantization of these lengths in simple rational ratios could take place for the preferred extremals.

4. Could the pulse shape associated with massless extremals (MEs, topological light rays) allow to distinguish classically between speech and music at the level of space-time correlates? Linear superposition of Fourier components in the direction of ME is possible and this allows to speak about pulse shape. It allows also the notions of coherent state and Fock state for given direction of wave vector. Essential would be the restriction of the superposition of fields in single direction of propagation to be distinguished from the superposition of the effects of fields associated with different space-time sheets on multiply topologically condensed particle. Maybe this would allow to make testable predictions.

8.6 Pythagoras, Music, Sacred Geometry, And Genetic Code

The conscious experiences generated by music demonstrate a fascinating connection between algebra and emotions. How can major and minor scale using different frequency ratios generate so different emotional experiences. This strongly suggests the we experience music as entire time interval, 4-D patterns - rather than time=constant snapshots. Also the ability remember the key and the tension lasting as long as the return to the basic key has not taken place, is example of this. One of the key questions is why octaves - that is powers of 2 of the basic note of the scale are experienced as equivalent? One can also wonder what is behind consonance and dissonance.

I have already earlier tried to understand music experience and considered some ideas inspired by p-adic numbers fields - such as the idea that Pythagorean scale coming as powers of 3 for the basic note modulo octave equivalence might relate to 3-adicity. Reading of a book titled "Interference: A Grand Scientific Musical Theory" by Richard Merrick [J97] freely available in web (http://tinyurl.com/8d2hfka) re-stimulated my interest. In particular, I found the idea about a connection between music scale and harmonies with Platonic solids (3-D "sacred geometry") as highly inspiring. The basic question was whether the 12-tone scale could be mapped to a curve going once through each point of icosahedron having 12 vertices and whether the 20 faces of icosahedron, which are triangles could define the basic chords in 12-tone scale. These curves are known as Hamiltonian cycles and in the case of icosahedron there are 2¹⁰ of them: those obtained from each other by rotation leaving icosahedron invariant are however equivalent.

A given triangle of icosahedron can contain 0, 1 or 2 edges of the cycle and the numbers of the triangles corresponding to these triangle types classify partially the notion of harmony characterized by the cycle. Quint cycle suggests the identification for the single edge of curve as quint interval so that triangles would represent basic 3-chords of the harmony with 0, 1, or 2 quints.

One can make same questions also for other Platonic solids- tetrahedron (4 vertices), octahedron and cube which are duals of each other and have (6 and 8 vertices respectively, and dodecahedron which is dual of icosahedron having 20 vertices and 12 faces. Arabic music uses half intervals and scales with 19 and 24 notes are used. Could 20-note scale with harmony defined by 5-chords assigned to the pentagons of dodecahedron have some aesthetic appeal? Nowadays it is possible to develop electronically music based on this kind of scale and this kind of experimentation might be a fascinating intellectual and artistic adventure for a young composer.

I have also played with the idea that the 20 amino-acids could somehow correspond to the 20 triangles of icosahedron. The combination of this idea with the idea of mapping 12-tone scale to a Hamiltonian cycle at icosahedron leads to the question whether amino-acids could be assigned with the equivalence class of Hamiltonian cycles under icosahedral group and whether the geometric shape of cycle could correspond to physical properties of amino-acids [I27]. The identification of 3 basic polar amino-acids with triangles containing no edges of the scale path, 7 polar and acidic polar amino-acids with those containing 2 edges of the scale path, and 10 non-polar amino-acids with triangles containing 1 edge on the scale path is what comes first in mind.

The number of DNAs coding for a given amino-acid [I13] could be also seen as such a physical property. The model for dark nucleons leads to the vertebrate genetic code with correct numbers of DNAs coding for amino-acids. It is not however clear how to interpret DNA codons geometrically.

It however turns out that one can understand only the role of 60 codons in the icosahedral framework. The treatment of the remaining 4 codons and of the well-known 21st and 22nd aminoacids requires the fusion of icosahedral code with tetrahedral code represented geometrically as fusion of icosahedron and tetrahedron along common face which has empty interior and is interpreted as punct coded by stopping codons. In this manner one can satisfy the constraints on the Hamiltonian cycles, and construct explicitly the icosahedral Hamiltonian cycle as (4, 8, 8) cycle whose unique modification gives (4, 11, 7) icosa-tetrahedral cycle. Remarkably, two months after writing the first version of the article I learned that the data needed to calculate the Hamiltonian cycles can be found from web and that (4, 8, 8) cycle allows at least two realizations whereas the original candidate (3, 10, 7) allows no realization with symmetries but could do so with no symmetries.

8.6.1 Could Pythagoras Have Something To Give For The Modern Musicology?

The ideas of Pythagorean school about music were strongly based on the number theory of that time. So called modern approaches tend to seem music scales as cultural phenomena. There are however many reasons to suspect that Pythagorean school might have been much nearer to truth.

Pythagoras and transition from rational numbers to algebraic numbers

Pythagoras was one the greatest ancient mathematicians. The prevailing belief at that was that the world can be described solely in terms rational numbers. During the times of Pythagoras the ancient mathematical consciousness had entered at the verge of a profound revolution: the time had become ripe for the discovery of algebraic numbers expanding rational numbers to an infinite series of algebraic extensions of rationals containing also rational multiples for finite number of algebraic numbers emerging as roots of polynomials with rational coefficients. Euclid introduces square root geometrically as length of the diagonal of square. In ancient India it was discover 800-500 BC, possibly much earlier. Unfortunately, the emergence of Christianity stopped the evolution of mathematics and new progress began at times of Newton when also reformation took place.

The well-known but story (good story but probably not true) tells that a pupil of Pythagoras demonstrated that the diagonal of unit square ($\sqrt{2}$) cannot be rational number and had to pay with his life for the discovery. Pythagoras himself encountered $\sqrt{2}$ through music theory. He asked what is the note exactly in the middle of the of the scale. Modern mathematician would answer half of octave corresponding to the frequency ratio $2^{1/2}$. Algebraic numbers did not however belong to the world of order of Pythagoras and he obtained to a non-satisfactory rational approximation of this number. This was very natural since only rational approximations of algebrais are possible in the experimental approach using only strings with rational number valued lengths. $\sqrt{2}$ represents the interval $C - F_{\#}$ known as tritone and this this interval was associated with devil and its use was denied also by church. Only after reformation $\sqrt{2}$ was accepted and this interval appears repeatedly in the compositions of Bach.

The amazing connections between evolution of mathematics and evolution of the religious beliefs inspires the question whether the evolution of consciousness could at basic level correspond to the evolution of the complexity of the number field behind the dynamics underlying consciousness. For instance, in TGD framework the vision about physics as generalized number theory allows one can to ask whether the mathematical evolution could have meant quite concretely the emergence of increasingly algebraic extensions of rationals for the coefficients of polynomials describing spacetime surfaces serving as space-time correlates of consciousness.

Pythagoras and music

Pythagoras was both mathematician and experimentalist studying the world of musical experience experimentally. String instruments were his tool. The notion of frequency was not know at the time and length of vibrating part of string was the notion used. The experienced equivalence of notes differing by octave was known at that time and octave equivalence was understood as a fundamental symmetry of music manifesting itself as a scaling-by-2 symmetry for the length of a vibrating string.

Pythagoras developed 8 note scale CDEFGAHC (as a matter fact, 7 notes by octave equivalence) as we know as a combination of two scales EFGA and HCDE using octave equivalence and it was established as the official music scale. Pythagorean scale is expressed solely in terms of rational number valued ratios of the string length to that for the basic note of the scale (ratio of frequency to the fundamental).

Pythagorean scale (http://tinyurl.com/28cu6j, http://tinyurl.com/7mc4ut) is expressed solely in terms of powers of the ratio 3/2 for lengths of vibrating strings correspond to an interval known and complete fifth (C-G). The series of complete fifths (C-G-D-A...) known as progression by fifths gives very nearly 7 octaves but not quite: $(3/2)^{12} \simeq 128 + 1.75 = 2^7 + 1.745$. It

would have been very natural to build 12-note scale as powers of rational (3/2) or by octave equivalence as powers of 3. The failure to close is very small but people with absolute ear experience the transponation of a melody to different key as dissonant since the frequency ratios do not remain quite same. At the time of Bach (Well tempered Klavier) the equal tempered scale obtained by diving the logarithmic scale to 12 equally long parts emerged and replacing powers of 3/2 with the 12 powers of algebraic number $2^{1/12}$ inside same octave even without octave equivalence emerged.

By octave equivalence Pythagorean scale means that all notes of the scale come in powers of 3 which strongly brings in mind 3-adicity. If one does not use octave equivalence when generalization of p-adicity to q-adicity with q = 3/2 is highly suggestive. q-adic numbers do not in general form number field, only an algebra.

Later more complex rational number based representations of scale using octave equivalence have been developed. The expression of the frequency ratios of the notes of the scale in terms of harmonic of fundamental modulo octave equivalence and involving only integers consisting of primes 2, 3, 5 is known as just intonation (http://tinyurl.com/7mc4ut).

1. Music and Platonic solids

Pythagoras was also aware of a possible connection between music scales and Platonic solids. Pythagoras is claimed to have discovered tetrahedron, hexahedron (cube) and dodecahedron while octahedron and icosahedron would have been documented by greek mathematician Thaletus two hundred years later. The tetrachord and was assigned with tetrahedron and one and imagined that Pythagorean scale could have been assigned with pair of tetrahedra somehow - cube or octahedron which comes in mind. Note that this would require that basic note and its octave should be regarded as different notes.

These attempts inspire the question whether the mapping music scales to the vertices of Platonic solids could provide insights about music experience. One can also ask whether there might be a mapping of music understood as melodies and chords in some scale to the geometries defined by Platonic solids.

- 1. Since 12-note scale is used in practically all classical western music and even in atonal music based on 12-note scale, the natural question is whether 12-note scale could be mapped to a connected, closed, non-self-intersecting path on icosahedron going through all 12 vertices and consisting of edges only. Closedness would mean that base note and its octave are identified by octave equivalence.
- 2. This mathematical problem is well-known and curves of this kind are known as Hamilton cycles and can be defined for any combinatorial structure defined by vertices and faces. Hamilton proved that Hamiltonian cycles (possibly identifiable as 20-note scale) at dodec-ahedron is unique module rotations and reflection leaving dodecahedron invariant. Also in the case of tetrahedron and cube the Hamiltonian cycle is unique.
- 3. For octahedron and icosahedron this is not the case [A5] and there are both cycles containing only faces with at least 1 edge of the path and also cycles containing no faces containing no edges of the path. Numerical experimentation is rather straightforward manner to determine Hamiltonian cycles and $H = 2^{10} = 1024$ cycles can be found. The number of topologically non-equivalent cycles (not transformable to each other by the isometries of icosahedron) is factor of this number. The group of orientation preserving isometries of icosahedron is the alternating group A_5 of 60 even permutations of five letters. The full group of isometries is $G = A_5 \times Z_2$ containing N = 120 elements.
- 4. Some subgroup of G leaves given path invariant and its order must be factor M of N so that topological equivalence class of cycles contains R = N/M elements. The number of topologically non-equivalent cycles in given class with H(top) elements is $N_{tot} = H(top)/R$ so that R must be a factor of H(top).

Before continuing it is good so summarize the geometry of icosahedron shortly. There are 20 faces which are triangles, 12 vertices, and 30 edges. From each vertex 5 edges. Therefore the construction of Hamiltonian cycles means that at each vertex on path one must select between four options edges since one cannot return back. This gives $4^{12} = 2^{24} \sim 1.6 \times 10^7$ alternatives to

be considered. Therefore the numerical search should be relatively easy. Keeping account of the points already traversed and not allowing self intersections, the actual number of choices is reduced. The construction requires labeling of the vertices of the icosahedron by integers 1, ..., 12 in some manner and defining 12×12 matrix A(i, j) whose element equals to 1 if vertices are neighbours and 0 if not. Only the edges for with A(i, j) = 1 holds true are allowed on the path. A concrete representation of icosahedron as a collection of triangles in plane with suitable identifications of certain edges is needed. This helps also to visualize the classification of triangles to three types discussed below. This can be found in the Wikipedia article (see http://tinyurl.com/ns9aa).

2. Numbers of different triangles as characterizers of harmony

A possible interpretation for topologically non-equivalent paths is as different notions of harmony.

- 1. Proceeding in Pythagorean spirit, the neighboring points would naturally correspond to progression by fifths that is scalings by powers of 3/2 or in equal temperated scale by powers of $2^{7/12}$. This would mean that two subsequent vertices would correspond to quint.
- 2. The twenty triangles of the icosahedron would naturally correspond to 3-chords. Triangles can contain either 0, 1, or 1 edges of the 12-edge scale path. The triangle containing 3 edges is not possible since it would reside on a self-intersecting path. A triangle containing one edge of path the chord would contain quint which suggest a chord containing basic note, quint and minor or major third. The triangle containing two edges would contain subsequent quints CDG is one possible example by octave equivalence. If the triangle contains no edges of the path one can say that the chord contains no quints.

The numbers of triangles classified according to the number of path edges contained by them serves as the first classification criterion for a given harmony characterized by the Hamiltonian cycle (note that one cannot exclude the possibly of non-closed paths since Pythagorean construction of the scale by quints does not yield quite precisely octave as outcome).

Fig 1. There are 3 different types of triangles characterized by the number of edges contained by them. This predicts chords with 0, 1 or 2 quints. http://tgdtheory.fi/appfigures/kolmiot.jpg

Consider now the situation in more detail.

1. The topologically equivalent cycles must have same numbers of faces containing 0, 1, or 2 edges of the Hamiltonian path since isometries do not change these numbers. Let us denotes these numbers by n_0, n_1 and n_2 . The total number of faces is 20 so that one has

$$n_0 + n_1 + n_2 = 20$$

Furthermore, each of the 12 edges on the path is contained by two faces so that by summing over the numbers of edges associated with the faces one obtains twice the number of edges:

$$0 \times n_0 + 1 \times n_1 + 2 \times n_2 = 2 \times 12 = 24$$
.

From these constraints one can solve n_0 and n_1 as function of n_2 :

$$n_0 = n_2 - 4$$
 , $n_2 \ge 4$,
 $n_1 = 24 - 2n_2$, $n_2 \le 12$.

If these integers characterize the topological equivalence completely and if the allowed combinations are realized, one would have 12-4=8 topologically nonequivalent paths. The actual number is $N_{tot} = 2^k$, $k \ge 7$, so that the integers cannot characterize the topology of the path completely. 2. The number of Hamiltonian cycles on icosahedron is known to be 2560 [A1]. Numerical calculations [A3] (http://tinyurl.com/pmghcwd) shows that the number of Hamiltonian cyclesw with one edge fixed is $2^{10} = 1024$. Here one regards cycles with different internal orientation as different. This would mean that the sum over the numbers $N(n_2)$ if cycles associated with differ values of n_2 satisfies

$$\sum_{n_2=4}^{12} \sum_{i} N(n_2, i)) = 2^{10}$$

 $N(n_2, i)$ is the number of paths of given topology with fixed n_2 . The numbers $N(n_2, i)$ are integers which are factors of N = 120 of the order of the isometry group of the icosahedron. The average of $N(n_2, i)$ is $2^7 = 128$.

3. Additional topological invariants characterizing the notion of harmony

The interpretation of amino-acids in terms of 20 triangles of icosahedron interpreted as allowed chords for a given notion of harmony leads to a unique identification of the integers n_i as $(n_0, n_1, n_2) = (3, 10, 7)$. The attempt to interpret this "biological harmony" leads to the identification of additional topological invariants characterizing the notion of harmony. It will be assumed that edges correspond to quints. If they would correspond to half-step the chords would contains 0, 1, or 2 subsequent half-intervals which does not conform with the usual views about harmony. In Pythagorean scale quint corresponds to 3/2 and in equal tempered scale quint corresponds to the algebraic number number $2^{7/12}$.

Above the attention was paid to the properties of the triangles in relation to the Hamiltonian cycle. One can consider also the properties of the edges of the cycle in relation to the two neighboring triangles containing it. Restrict first the attention to the biological harmony characterized by $(n_0, n_1, n_2) = (3, 10, 7)$.

Fig. 2. The edge of the cycle belongs to 2 triangles, which as chords can correspond to 1 resp.2, 1 resp. 1 and 2 resp. 2 quints.

http://tgdtheory.fi/appfigures/sivut.jpg

1. Everyone of the 12 quints C-G, $C_{\#}-G_{\#}$, ... would be contained to neighboring triangles the is 3-chords containing at least one quint. Denote by p_{12} , p_{11} resp. p_{22} denote the number of edges shared by 1-quint triangle and 2-quint triangle, by 2 1-quint triangles, resp. 2 2-quint triangles. Besides $p_{ij} \ge 0$ one has

$$\sum p_{ij} = 12 \ .$$

since the cycle contains 12 edges. There are $p_{12} + 2p_{11} = n_1$ 1-quint triangles and $(p_{12} + 2p_{22})/2 = n_2$ 2-quint triangles (note double counting responsible for division by two). Altogether this gives

$$p_{22} = 12 - p_{11} - p_{22} ,$$

$$p_{22} = p_{11} + n_2 - \frac{n_1}{2} ,$$

$$p_{22} = n_2 - \frac{p_{12}}{2} .$$

2. These three Diophantine equations are for integers and would allow for real numbers only single solution and for integers it in the generic case there are no solutions at all. Situation changes if the equations are not independent which can happen if the integers n_i satisfy additional conditions. By subtracting first and second and second and third equation from each other one obtains the consistency condition

$$n_1 = 24 - 2n_2$$
 .

This condition is however second of the conditions derived earlier so that only two equations, say the first two ones, are independent.

$$p_{22} = p_{11} + n_2 - \frac{n_1}{2} ,$$

$$p_{22} = n_2 - \frac{p_{12}}{2} .$$

giving

$$p_{11} = (n_1 - p_{12})/2 ,$$

$$p_{22} = p_{11} + n_2 - \frac{n_1}{2} = n_2 - \frac{p_{12}}{2} .$$

One must have $0 \leq p_{ij} \leq 12$ and $p_{12} \leq n_1$ from $p_{11} = (n_1 - p_{12})/2$. Here one has $p_{12} \in \{0, 2, \dots Min\{12, 2n_2, n_1\}$ so that $Min\{7, n_2 + 1, [n_1/2] + 1\}$ solutions are possible. The condition that the cycle has no self-intersections can forbid some of the solutions.

3. The first guess for the "biological harmony" possibly associated with amino-acids would be $(n_0, n_1, n_2) = (3, 10, 7)$: this if one neglects the presence of 21st and 22th amino-acid also appearing in proteins. It turns out that a more feasible solution fuses tetrahedral code and icosahedral codes with $(n_0, n_1, n_2) = (4, 8, 8)$ giving $(n_0, n_1, n_2) = (4, 11, 7)$ for icosatetrahedral code.

For instance, $(n_0, n_1, n_2) = (3, 10, 7)$ would give $p_{12} \in \{0, 2, 4, 6, 8, 10\}$, $p_{11} \in \{5, 4, 3, 2, 1, 0\}$, $p_{22} \in \{7, 6, 5, 4, 3, 2\}$ so that one has 6 alternative solutions to these conditions labelled by p_{12} . The number of neighboring triangles containing single quint is even number in the range [0, 10]: this brings in mind the possibility that the neighboring single quint triangles correspond to major-minor pairs. Clearly, the integer p_{12} is second topological invariant characterizing harmony.

4. Distribution of different types of edges

Also the distribution of the 12 edges to these 3-types is an invariant characterizing the shape of the curve and thus harmony as isometric invariant.

Fig. 3. There are different distributions of edge types characterized by the neighboring triangles of the edge.

http://tgdtheory.fi/appfigures/jakauma.jpg

1. p_{12} 1-1 edges can be chosen in

$$N(1-1,p_{12}) = \left(\begin{array}{c} 12\\p_{12}\end{array}\right)$$

ways and 1-2 edges in

$$N(1-2, p_{12}) = \begin{pmatrix} 12 - p_{12} \\ p_{12} \end{pmatrix}$$

ways. The remaining 2-2 edges can be chosen only in one manner. This gives altogether

$$N(p_{12}) = N(1-1, p_{12}) \times N(1-2, p_{12})$$

ways for given value of p_{12} .

To summarize, one obtains large number of notions of harmony are possible although one cannot expect that the absence of self-intersections does not allow all topologies for the cycle.

Would you come with me to icosadisco?

This map would allow one-to-one map of the notes of any music piece using icosahedral geometry. If octave equivalence is assumed, a given note would be mapped to a fixed vertex of icosahedron at which lamp is turned on and also to the wavelength of the light in question since visible light spans an octave. Chords would correspond to the turning on of lights for a group of icosahedral points. Icosahedrons with size scaled up by two could correspond to octave hierarchy: for practical purposes logarithmic scale implying that icosahedrons have same distance would be natural as in the case of music experience since piano spans 7 octaves and human ear can hear 10 octaves. Church would nowadays allow icosadiscos to use also half octaves to amplify further the audiovisual inferno effect so characteristic for discos. One could also try to realize special effects like glissandos, vibratos and tremolos.

8.6.2 Connection Between Music Molecular Biology?

Music affects directly emotions, and consciousness is one aspect of being living. This raises the question whether the Platonic geometries might have something to do with basic building bricks of life and with genetic code.

Could amino-acids correspond to 3-chords of icosahedral harmony?

The number of amino-acids is 20 and same as the number of triangular faces of icosahedron and the vertices of dodecahedron. I have considered the possibility that the faces of icosahedron could correspond to amino-acids [K6]. Combined with the idea about connection between music scale and icosahedron this inspires the following consideration.

- 1. For a proper choice of the mapping of the 12-note scale to the surface of icosahedron the 20 triangles could correspond to 20 amino-acids analogous to 3-chords and that the 3 types of 3-chords could correspond to 3 different classes of amino-acids. One can of course consider also the mapping of amino-acids to a unique sequence of 20 vertices of dodecahedron representing 20-note scale or 20-chord scale and replacement of the 3-chords defining the harmony with 12 5-chords.
- 2. Amino-acids are characterized by the non-constant side chain and these can be classified to three categories: basic polar, non-polar, and polar (http://tinyurl.com/ycvm6yjs). The numbers of amino-acids in these classes are $a_0 = 3$, $a_1 = 10$, $a_2 = 7$. Could these classes correspond to the numbers n_i characterizing partially some topological equivalence classes of Hamiltonian paths in icosahedron? There is indeed a candidate: $a_0 = n_0 = 3$, $a_1 = n_1 = 10$, $a_2 = n_2 = 7$ satisfies the conditions discussed above. 3 basic polar amino-acids would correspond to the triangles with no edges on the Hamiltonian cycle, 10 non-polar amino-acids to those containing two edges. One can criticize the combination of polar and acidic polar amino-acids to those containing two edges. One can also classify amino-acids to positively charged (3), negatively charged (2) and neutral (15) ones. In this case the condition is however not satisfied. Thus the proposal survives the first test assuming of a course that these Hamiltonian cycles exist! This has not been proven and would require numerical calculations.
- 3. As found Hamiltonian paths have also other topological characteristics and they could correspond to physical characteristics and it would be interesting to see what they have. To proceed further one should find the total number of the Hamiltonian paths with $n_2 = 7$ and identify the isometries of different topological equivalence class having $n_2 = 7$.

Amino-acid sequences would correspond to sequences of 3-chords. The translation of mRNA of gene to amino-acid sequence would be analogous to the playing of a record. The ribosome complex would be the record player, the amino-acid sequence would be the music, and mRNA would be the record. Hence genes would define a collection of records characterizing the organism.

d	6	4	3	2	1
Ν	3	5	2	9	2

Table 8.2: The number of amino acids N associated with a given degeneracy d telling the number of DNA triplets mapped to the amino acid in the genetic code. The degeneracies are always smaller than 7 as predicted by the proposed explanation of the Genetic Code.

Can one understand genetic code?

What remains open is the interpretation of genetic code [I13]. DNA triplets would correspond naturally to triangles but why their number is 64 instead of 20. They would be obviously the analogs of written notes: why several notes would correspond to the same chord?

- 1. Could different DNA triplets coding for the same amino-acid correspond to various octaves of the chord? The most natural expectation would be that the number of octaves so that one would have 3 DNAs would code single amino-acid and stopping codon would correspond to 4 DNAs. It is difficult to understand why some 3-chords could correspond to 6 octaves and one of them only one.
- 2. Could the degeneracy correspond to the ordering of the notes of the 3-chord? For the 3-chords there are 6 general orderings and 3 cyclic orderings modulo octave equivalence and characterizing by the choice of the lowest note. The simplest assumption would be that the allowed orderings degeneracies are characterized by a subgroup of the cyclic group S_3 yielding the allowed permutations of the notes of the chord. The subgroup orders for S_3 are 1, 2, 3, and 6. The allowed degeneracies are 6, 4, 3, 2, and 1 so that this identification fails for D = 4.
- 3. Could the different correspondences between DNA codons and amino-acids correspond to the different topological equivalence classes of $n_2 = 7$ Hamiltonian cycles. This does not seem to be the case. The number of different DNA-amino-acid correspondences obtained by choosing one representative from the set of DNAs coding for a given amino-acid (and not stopping sign) is the product of the numbers $D(a_i)$ coding amino-acid a_i . From **Table 8.2** this number is given by $6^3 \times 4^5 \times 3^1 \times 2^9 \times 1^2 = 3^4 \times 2^{21}$ and clearly much larger than $N = 2^{10}$.
- 4. Could the different codons coding for codon code for some additional information so that amino-acids would in some aspect differ from each other although they are chemically identical? Here the magnetic body of amino-acid is a natural candidate. This would suggest that the folding pattern of the protein depends on what DNA sequence codes it. This information might be analogous to the information contained by notes besides the frequencies. Durations of notes corresponds is the most important information of this kind: the only candidate for this kind of information is the value of $h_{eff} = n \times h$ associated with the amino-acid magnetic body determining its size scale. Magnetic fields strength could be also code by DNA codon besides amino-acid.

Second question concerns genetic code itself. Could the DNA degeneracies $D(a_i)$ (number of DNAs coding for amino-acid a_i) be understood group theoretically in terms of icosahedral geometry? The triangles of the icosahedron are mapped the triangles under the isometries.

- 1. One can start by looking the **Table 8.2** for the genetic code telling the number N(d) of amino-acids coded by d DNA codons. One finds that one can divide DNAs to three groups containing n = 20, n = 20, resp. n = 21 codons.
 - (a) There are 3 amino-acids codes by 6 codons and 2 amino-acids coded by 1 DNA: 3×6+2×1 = 20 codons altogether.
 Note: One could also consider 1 amino-acid coded by 2 codons instead of 2 coded by 1 codon 3×6+1×2 = 20.
 - (b) There are 5 amino-acids coded by 4 codons making $5 \times 4 = 20$ codons altogether.

(c) There are 9 amino-acids coded by 2 codons and 1 by 3 codons making $9 \times 2 + 1 \times 3 = 21$ codons.

Note: One could also consider the decomposition $8 \times 2 + 2 \times 1 + 1 \times 3 = 21$ codons implied if 1 amino-acid is coded by 2 codons in the first group.

This makes 61 codons. There are however 64 codons and 3 codons code for stopping of the translation counted as punct in the table.

- 1. This would suggest the division to 60 + 4 codons. The identification of additional 4 codons and corresponding amino-acids is not so straightforward as one might first think. 3 of the 4 additional codons could code for punct (Ile) and 1 of them to Ile (empty amino-acid).
- 2. What suggests itself strongly is a decomposition of codons in 3 different ways. 3 groups of 6 codons plus 2 groups of 1 codon (1 group of 2 codons), 5 groups of 4 codons, and 10 groups of 2 codons (9 groups of 2 codons plus plus 2 groups of 1 codon).

This kind of decompositions are induced by the action on the triangles of icosahedron by three subgroups of the isometry group $A_5 \times Z_2$ of the icosahedron having $120 = 2 \times 2 \times 2 \times 2 \times 3 \times 5$ elements and subgroups for which number of elements can be any divisor of the order. The orbit associated with a subgroup with *n* elements has at most *n* triangles at its orbit. This allows immediately to deduce the values of *n* possibly explaining the genetic code in the proposed manner.

- 1. The 3 amino-acids coded by 6 codons must correspond to n = 6. This subgroup must have also two 1-element orbits (1 2-element orbit): in other words, 2 triangles must be its fixed points (form its orbit).
 - (a) The non-abelian group S_3 permuting the vertices of is the first candidate for the subgroup in question. The triangles at the opposite sides of the icosahedron remain invariant under these permutations. S_3 however has two orbit consisting of 3 triangles which are "wall neighbours" of the triangles which remains fixed.
 - (b) Second candidate is the abelian group $\tilde{Z}_2 \times Z_3$. Here Z_3 permutes the vertices of triangle and \tilde{Z}_2 is generated by a reflection of the triangle to opposite side of icosahedron followed by a rotation by π . This group has 3 orbits consisting of 6 triangles and 1 orbit consisting of 2 triangles (the triangles at opposite side of icosahedron). This group seems to be the only working candidate for the subgroup in question.
- 2. The 5 amino-acids coded by 4 codons must correspond to n = 4 and therefore to $\hat{Z}_2 \times Z_2$. This is indeed subgroup of icosahedral group which permutes triangles at the vertices of inscribed tetrahedron. Now all orbits contain 4 triangles and one must have 5 orbits, which are obtained by acting on the 5 triangles emanating from a given vertex. Note that also Z_5 is subgroup of icosahedral group: this would give a variant of code with 4 amino-acids coded by 5 codons if it were possible to satisfy additional consistency conditions.
- 3. Consider next the group consisting of 9 amino-acids coded by 2 codons and Ile ("empty" amino-acid) coded by 3 codons. Since only the $\tilde{Z}_2 \times Z_3$ option works, this leaves 9 amino-acids coded by 2 codons and 2 amino-acids coded by 1 codon. The subgroup must correspond to n = 2 and thus Z_2 acting on fixed triangle and leaving it and its \tilde{Z}_2 image invariant. One has 9 2-triangle orbits and two single triangle orbits corresponding to the triangles at opposite sides of the icosahedron. The 9 amino-acids coded by 2 codons are all real or 8 of them are real and 1 corresponds to "empty amino-acid" coded by two codons.

3-element orbits are lacking and this forces to consider a fusion of of icosahedral code with tetrahedral code having common "empty-acid" - common triangle of icosahedron and tetrahedron) coded by 2 icosahedral codons and 1 tetrahedral codon. Ile would be coded by 3 codons assignable to the orbit of Z_3 subgroup of tetrahedral symmetry group S_3 and would be associated with the tetrahedron. This would predict 2 additional amino-acids which could be understood by taking into account 21st and 22nd amino-acid (Sec and Pyl [I27]).

The Hamiltonian cycle is not explicitly involved with the proposed argument. Some property of the cycle respected by the allowed isometries might bring in this dependence. In Pythagorean spirit one might ask whether the allowed isometries could leave the Hamiltonian cycle invariant but move the vertices along it and induce a mapping of faces to each other.

The amino-acid triangle at given orbit cannot be chosen freely. The choices of amino-acid triangles associated with the three groups of 20 DNAs must be different and this gives geometric conditions for the choices of the three subgroups and one can hope that the assignment of amino-acid toa given triangle is fixed about from rotational symmetries.

Does the understanding of stopping codons and 21st and 22nd amino-acids require fusion of tetrahedral and icosahedral codes?

Several questions remain. Could one also understand the additional 4 DNA codons? Could one understand also how one of them codes amino-acid (Ile) instead of stopping codon? Can one related additional codons to music?

1. Attachment of tetrahedron to icosahedron as extension if icosahedral code

The attachment of tetrahedron to icosahedron allows to understand both stopping codons and punct as well as the 21st and 22nd amino-acids geometrically.

- 1. Something is clearly added to the geometric structure, when at least 4 additional DNA codons and 2 amino-acids are brought in. The new codons could represent orbits of faces of Platonic solid with 4 faces representing punct and 3 real amino-acids: say Ile, Pyl, and Sec. The 4 faces should be triangles and actually must be so since tetrahedron is the only Platonic solid having 4 faces and its faces are indeed triangles. Tetrahedron has symmetry group S_3 containing Z_3 and Z_2 as subgroups. Z_3 leaves one of the tetrahedral triangles invariant so that one has two orbits consisting of 1 and 3 triangles respectively.
- 2. One amino-acid is coded by 3 rather than only 2 codons. One can indeed understand this symmetry breaking geometrically. Suppose that the tetrahedron is attached on icosahedron along one of its triangular faces and that this icosahedral face corresponds either Ile or punct coded by 2 icosahedral codons. This face remains also fixed by the action of Z_3 and S_3 subgroups of tetrahedron so that 1 tetrahedral codon codes also for the amino-acid in question.
- 3. The three other faces of tetrahedron r should bring in three additional amino-acids. punct could correspond to either one of them or to the common base triangle which is indeed geometrically in unique position. One could even demand that this triangle is "empty" so that tetra-icosahedron would be non-singular continuous manifold. The 3-triangle orbit outside the icosahedron would correspond to IIe and base triangle to empty amino-acid. Base triangle would be coded by 1 tetrahedral codon plus 2 icosahedral codons.
- 4. One of the outsider triangles would thus corresponds to Ile but two other triangles to two new exotic amino-acids. In some species there indeed are 21st and 22nd amino-acids (seleno-cysteine (Sec) and pyrrolysine (Pyl), http://tinyurl.com/2byr2b) with sulphur replaced with selene. This modification does not change the polarity properties of cys and lys: cys and thus Sec is non-polar and lys and thus Pyl is basic polar implying $(n_0, n_1, n_2) = (3, 10, 7) \rightarrow (4, 11, 7)$.
- 5. The two other outsider tetrahedral triangles could correspond to the orbits of Z_2 subgroup of S_3 acting as reflection with respect to median of the base triangle. Outside faces form orbits consisting of 1 triangle and 2-triangles. Could these orbits correspond to 21st and 22nd amino-acids coded by 1 and 2 exotic codons?

Since Ile and Sec are non-polar, they can correspond to 1-quint triangles at tetrahedron. 2-quint triangle cannot however correspond to Pyl which should correspond 0-quint triangle. Hence the 0-quint triangle must be at the isosahedron and the 2-quint triangle must correspond to basic polar amino-acid coded by single codon: Tyr is the only possible option). Hence the tetrahedral amino-acids are fixed to be Ile, Sec, and Tyr and Pyl must correspond to some icosahedral amino-acid. The second implication is that the icosahedral Hamiltonian cycle from which the icosate trahedral cycle is obtained as deformation must correspond to (4, 8, 8) since one cannot deform (3, 7, 10) in such a manner that one would obtain one additional 0-quint triangle.

It should be noticed that the 2 exotic amino-acids are coded by codons which are usually interpreted as stopping codons. Something must however distinguish between standard and exotic codings. Is it "context" giving different meaning for codons and perhaps characterized by different magnetic bodies of codons [K99] ?

Fig. 4. tetra-icosahedron is obtained by attaching tetrahedron along one of its faces to icosahedron. The resulting structure is topological manifold if the common face is replaced with empty set and it is natural to identify it as punct. http://tgdtheory.fi/appfigures/tetra-icosahedron.jpg

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2. How the icosahedral Hamiltonian cycle is modified?

The properties of exotic amino-acids give constraints on how the modification of the Hamiltonian cycle should be carried out. The naïve expectation that the outer triangles of added tetrahedron correspond to punct and 2 exotic amino-acids is not correct. A more appropriate interpretation is as a fusion of icosahedral and tetrahedral codes having common "empty aminoacid" coded 2 icosahedral and 1 tetrahedral 1 stopping codons respectively and obtained by gluing these Platonic solids together along the triangle representing the "empty" amino-acid. That the common triangle corresponds to punct means geometrically that its interior is not included so that the resulting structure is continuous manifold having topology of sphere.

Consider now the detailed construction.

- 1. One should be able to modify the icosahedral Hamiltonian cycle so that the numbers (n_0, n_1, n_2) charactering icosahedral cycle change so that they conform with the properties of the two exotic amino-acids. Selenocystein (Sec) is nonpolar like cys and pyrrolysine (Pyl) basic polar like Lys so that (4, 11, 7) seems to be the correct characterization for the extended system. One must have $(n_0, n_1, n_2) \rightarrow (4, 11, 7)$.
- 2. One must visit the additional vertex, which means the replacement of one edge from the base triangle with wedge visiting the additional vertex. There are several cases to be considered depending on whether the base triangle is 1-quint triangle or 2-quint triangle, and what is the type of the edge replaced with wedge. One can even consider the possibility that the modified cycle does not remain closed.

If the icosahedral cycle has $(n_0, n_1, n_2) = (3, 10, 7)$, the value of n_2 is not changed in the construction. For a closed cycle edge is replaced with wedge and the only manner to preserve the value of n_2 is that the process producing 1 tetrahedral 2-quint triangle transforms 1 icosahedral 2-quint triangle identified as base triangle to 1-quint triangle. If the replaced edge of base triangle is of type 2-1, one has $n_1 \rightarrow n_1 + 1$ since one icosahedral 1-quint triangle disappears and 2 tetrahedral ones appear. Icosahedral n_0 increases by 1 units. Hence the condition $(3, 10, 7) \rightarrow (4, 11, 7)$ would be met. It however seems that (4, 8, 8) is more promising starting cycle as the argument below shows.

3. The number options is at most the number n_2 of 2-quint triangles serving as candidates for punct. An additional condition comes from the requirement that replaced edge is of type 2-1.

Fig. 4. tetra-icosahedron is obtained by attaching tetrahedron along one of its faces to icosahedron. The resulting structure is topological manifold if the common face is replaced with empty set and it is natural to identify it as punct.

Fig. 5. The modification of (4, 4, 8) icosahedral Hamiltonian cycle consistent with the constraints that icosatetrahedral cycle corresponds to (4, 11, 7) consistent the classification of aminoacids in three classes.

http://tgdtheory.fi/appfigures/tetraikosahedroni.jpg

3. Direct construction of Hamiltonian cycle corresponding to bio-harmony

Consider bio-harmony as an example about Hamiltonian cycle taking seriously the extension of the genetic code. I have made very many unsuccessful triangles starting from the assumption that icosahedral cycle satisfies $(n_0, n_1, n_2) = (3, 10, 7)$, and the following proposal starts from different icosahedral cycle. The following is just a trial, which should be checked by a direct calculation.

- 1. The most obvious guess for the cycle to be modified to cycle at tetra-icosahedron having $(n_0, n_1, n_2) = (4, 11, 7)$ (the triangle corresponding to "empty" amino-acid (to be called punct) is not counted) is $(n_1, n_2, n_3) = (3, 10, 7)$. I have not found cycle with these characteristics.
- 2. It seems however possible to find cycle with $(n_1, n_2, n_3) = (4, 8, 8)$. From this can obtain the desired kind of extended cycle if the "empty" triangle is 2-quint triangle and the edge replaced with the wedge is of type 2-2. The replacement of icosahedral edge eliminates two icosahedral 2-quint triangles and generates 1 tetrahedral 2-quint triangle giving $n_2 \rightarrow$ $n_2 - 2 + 1 = n_2 - 1 = 7$. The disappearance of the icosahedral edge generates two icosahedral 1-quint triangles of which second one corresponds to empty amino-acid and is not counted and 2 tetrahedral 1-quint triangles giving $n_1 \rightarrow n_1 + 3 = 11$.

The figure below represents the construction of cycle (4, 8, 8,). The icosahedron is constructed from regions P(I) glued to the triangle t along one edge each. The arrows indicate that the one pair of edges of type 1 and 2, 1 and 3 and 3 and 2 are identified. Also the long edges I of T are identified with pairs of subsequent edges of P(I) as the arrows indicate.

Fig. 6. A proposal for a Hamilton cycle realizing bio-harmony $(n_1, n_2, n_3) = (4, 8, 8)$ allowing extension to cycle (3, 11, 7) on tetra-icosahedron. Circled "0", "1" and "2" indicates whether a given small triangle is 0-, 1-, or 2-quint triangle. It is relatively easy to verify that the condition $(n_1, n_2, n_3) = (4, 8, 8)$ for bio-harmony is satisfied. http://tgdtheory.fi/appfigures/aikosahedroni.jpg

4. Stopping codons and music

What could be the interpretation of the attached tetrahedron in terms of music harmony? The attachment of tetrahedron means addition of an additional note to the 12-note scale. The scale constructed in Pythagorean spirit identifying quint as scaling by 3/2 contains the 12th note as scaling by $(3/2)^{12}$ of the basic frequency modulo octave equivalence. This is slightly more than scaling by 2^7 so that exact octave is not obtained. The attempt to solve this problem has lead to scales in which one allows a pair of notes with a very small interval between them - say $G_{\#}$ and A_b being regarded as different notes.

This suggests that the outsider vertex of the attached tetrahedron corresponds to a note very near to some note of the 12-note scale. Which note is in question depends on which of the 10 1-quint triangles is chosen as the base triangle. This is expected to imply additional refinements to the notion of bio-harmony. 2 or three additional 3-chords emerge depending on whether empty amino-acid is interpreted as a real chord.

5. Geometric description of DNA-amino-acid correspondence

The mathematical structure which suggests itself is already familiar from some earlier attempts to understand genetic code [K61]. For icosahedral part of code one would have a discrete bundle structure with 20 amino-acids defining the base space and codons coding the amino-acid forming the fiber. The number of points in the fiber above based point depends on base point and is the number of codons coding the corresponding amino-acid. A discrete variant of singular fiber bundle structure would be in question.

Forgetting for a moment the 4 troublesome codons, the bundle would be the union of the orbits associated with groups S_3 , Z_4 and Z_2 of icosahedral group, and the base would consist of 20 amino-acids, one for each orbit. The point of orbit must be selected so that the selections for orbits of two different groups are different.

The addition of the additional codons, punct and two exotic amino-acids would mean gluing of tetrahedron along one of its faces to icosahedron. This would induce extension of the singular bundle like structure. To each of the new faces one would attach the orbit of triangles representing the codons coding for the corresponding amino-acid.

To sum up, in its strongest form the model makes several purely mathematical predictions, which could easily kill it.

- 1. The identification of the 3-chords assignable to the triangles of the icosahedron.
- 2. The existence of $n_2 = 7$ Hamiltonian cycle requiring however the lumping of acidic polar and polar amino-acids in the same class.

How could one construct the Hamiltonian cycles on icosahedron with a minimal computational work?

Although the construction of Hamiltonian cycles is known to be an NP hard problem for a general graph, one can hope that in case of Platonic solids having high symmetries, a direct construction instead of straightforward numerical search might work. The following a proposal for how one might proceed. It relies on paper model for icosahedron.

- 1. The basic observation about one can get convinced by using paper model is following. One can decompose the surface of icosahedron to three regions P(I), I = 1, 2, 3, with pentagonal boundary and containing 5 triangles emanating from center vertex plus one big triangle T containing 4 pentagonal triangles and one lonely small triangle t opposite to it. These 5 regions span the surface of icosahedron. There is clearly a symmetry breaking and there is great temptation to assume that t corresponds to the triangle along which the tetrahedron is glued to the icosahedron in the model of genetic code realizing the modification of (3, 7, 10) bio-harmony.
- 2. The Hamiltonian cycle must visit at the centers of each P(I): one enters pentagonal region P(I), I = 1, 2, 3 along one of the five interior edges beginning at pentagonal vertex $a_{I,i}$, i = 1, ..., 5 and leaves it along second edge ending at vertex $b_{I,j}$, $j \neq 5$. One can call these edges interior edges. The edges at boundaries of P(I) can be called boundary edges. Interior edge can correspond to |i j| = 0, 1 or i j > 1. For |i j| = 1 the interior edge gives rise to 2-quint triangle. For i j = 0 there is no boundary edge after $b_i(I, j)$.
- 3. Pentagonal boundary edges come in three types. 2 of them are shared with T, 1 with t opposite to it, and 2 with another pentagonal region P(I). One can label P(i) in such a way that the P(I) shares two boundary edges with P(I+1).

The boundary edges of small and big triangle are boundary edges of the 3 pentagonal regions so that they are not counted separately.

4. One can assume that the cycles begins from a vertex of T. Since the cycle is closed it returns back to this vertex. The last edge is either at the boundary of T or goes through one or two edges of the small interior triangle of T so that this triangle is either 0-, 1- or 2-quint triangle.

t can be 0-, 1-, or 2-quint triangle.

- 5. The total number of the interior edges inside the 3 pentagonal regions is $3 \times 2 = 6$ so that 6 remaining edges must be boundary edges associated with P(I) and interior edges of T: otherwise one would visit some pentagonal center twice and self-intersection would occur. The boundary edges associated with t and T are boundary edges of P(I), I = 1, 2, 3
- 6. At the vertex $b_{(I, j)}$ of pentagonal region one must turn right or left and move along the boundary edge. One can move at most $n_I = 4 j$ boundary edges along the pentagonal boundary in clockwise direction and $n_I = j-2$ edges in counterclockwise direction (clockwise is the direction in which the index labelling 5 vertices grows). The maximum number of boundary edges is 3 and obtained for $j i \pm 1$.
- 7. The condition $\sum n_I + n(T) = 6$, where n(T) = 1, 2 is the number of interior edges of T, holds true so that one has $\sum n(I) \equiv n_{tot} \in \{4, 5\}$. The numbers and types (shared with pentagon,

T, or t) of the boundary edges of P(I), the differences $\Delta(I) = j_I - i_I$, the number of edges in t and the number of interior edges of T characterize the Hamiltonian cycle besides the condition that it is closed. The closedness condition seems possible to satisfy. One must enter big triangle through one of the vertices of T and this vertex is uniquely determined once the third pentagon is fixed. One can therefore hope that the construction gives directly all the Hamiltonian cycles with relatively small amount of failed attempts, certainly dramatically smaller than $n = 2^{24} \sim 10^7$ of blind and mostly un-succesful trials.

8. Each P(I) containing boundary edges gives rise to least 2 2-quint triangles associated with $b_I(I)$ and a_{I+1} .

If all 3 P(I) have |i-j| > 1, one has $n_2 = 3 \times 2 = 6$. The contribution of regions P(I) is larger if some pentagon interiors have $|\Delta(I)| = |j(I) - i(I)| = 1$. |j(I) - i(I)| = 1 gives $\Delta n_2(I) = 1$ and $\Delta n_1(I) = 0$ since 2 1-quint triangles are replaced with single 2-quint triangle.

The interior of the T can give 1 2-quint triangle.

- 9. The number n_1 of 1-quint triangles can be estimated as follows.
 - (a) Each pentagonal interior edge pair leading from a(I,j) to b(I,j) contributes 2 1-quint triangles for $\Delta(I) \neq \pm 1$, otherwise one obtains only 1 2-quint triangle. This would give maximum number of 6 1-quint triangles associated with the interior edges of 3 pentagons.
 - (b) P(I) pentagonal boundary edges contribute $2 \times (P(I) 1)$ additional 1-quint triangles.
 - (c) T contributes at most 4 1-quint triangles.
 - (d) t can correspond 1-quint triangle and would do so if the interpretation of extended code is correct.
- 10. The construction also breaks the rotational symmetry since the decomposition of icosahedron to regions is like gauge fixing so that one can hope of obtaining only single representative in each equivalence class of cycles and therefore less than 2^{10} . By the previous argument related to icosatetrahedral code, t and the triangle opposite to it cannot however correspond to amino-acids coded by 1 codon as one might guess first. Rather, t corresponds to punct and to 1-quint triangle belonging to Z_2 orbit.

The number of cycles should be 2^{10} . One can try to estimate this number from the construction. Each $b_{I,j}$ can be chosen in 4 ways at the first step but at later steps some vertices of the neighboring pentagon might have been already visited and this reduces the available vertices by n + 1 if n subsequent edges are visited. At each vertex $b_{I,j}$ one has 4 options for the choice of the boundary edges unless some boundary edges of pentagon (shared with other pentagons) have been already visited. It is also possible that the number of boundary edges vanishes. One can start from any vertex of triangle. This gives the upper bound of 2^4 choices giving $N < 2^{12}$ paths going through 4 pentagon-like regions. The condition that the path is closed, poses constraints on the edge path assignable to T but the number of choices is roughly 24. The condition that path goes through all vertices and that no edge is traversed twice must reduce this number to 2^{10} .

The numerical construction of Hamiltonian cycles should keep account about the number of vertices visited and this would reduce the number of candidates for b(I, j) and for the choices of P(I) for I > 1 as well as the number of edge paths associated with T.

Icosahedral Hamiltonian cycles numerically

A couple of months after writing the article I decided to look at the numerical problem of calculating the Hamiltonian cycles for icosahedron. Recall that the earlier source [A3] (http://tinyurl.com/pmghcwd) telling that there are 2^{10} different Hamiltonian cycles when orientation is taken into account and one edge is fixed: if orientation does not matter there re 2^9 cycles. If one does not fix one cycle one obtains 2560 cycles - not Hamiltonian paths as I had erratically concluded. The cycles were actually listed (http://tinyurl.com/yacgzm9x) and classified to five different basic classes according to their symmetries. Even better, examples of cycles with symmetries were illustrated.

Cycles can be divided to isomorphy classes within which cycles have same shape.

- 1. It is possible to perform a shift of the edges along the cycle. The shape of the cycle is not affected but cycle changes. Using music terms the key changes. There are 12 different keys.
- 2. Also the mirror image mapping i^{th} edge to $(13-i)^{th}$ edge is a symmetry which in the generic case produces a new cycle. This symmetry should be distinguished from the change of the internal orientation which does not affect the cycle.
- 3. Also the isometries of icosahedron leaving the fixed edge as such act as symmetries. Fixed edge belongs to a triangle and the reflection mapping the two other edges of the triangle to each other is this kind of symmetry. Therefore there are two reflection symmetries and the number of cycles of same shape in the generic case is expected to be $4 \times 12 = 48$. If some of the symmetries acts trivially or if some isometries of icosahedron act as its symmetries, the number of isomorphic cycles is reduced.

It is even possible to find illustrations of the symmetric cycles (http://tinyurl.com/ y8ek7ak8) obtained using Brendan McKay's NAUTY software (http://tinyurl.com/dkftsr)! From these illustrations (see Figs. 8.1, 8.3 and 8.2) one can by visual inspection deduce the numbers (n_0, n_1, n_2) charactering the cycle for classes involving symmetries. Also the basic chords can be deduced. If one trusts the condition $n_1 + 2 \times n_2 = 24$, it is enough to count the number n_2 triangles containing to path edges. I have also directly checked that n_1 comes out correctly.



Figure 8.1: $((n_0, n_1, n_2) = (4, 8, 8)$ Hamiltonian cycle with 2 reflection symmetries acting in vertical and horizontal directions.

There are following isomorphic collections.

- 1. 6 asymmetric collections containing the maximal number of 48 cycles each. In this case images are not given.
- 2. 3 collections with 2-fold rotation symmetry containing 48/2=24 cycles each. One has $(n_0, n_1, n_2) \in \{(0, 16, 4), (0, 16, 4), (4, 8, 8)\}.$
- 3. 5 collections with reflectional symmetry containing 48/2=24 cycles each. One has $(n_0, n_1, n_2) \in \{(2, 12, 6), (2, 12, 6), (4, 8, 8), (2, 12, 6), (2, 12, 6)\}$.
- 4. 2 collections with 2 reflectional symmetries containing 48/4=12 cycles each. One has $(n_0, n_1, n_2) \in \{(0, 16, 4), (4, 8, 8)\}$.
- 5. 1 collection with 6-fold rotational symmetry containing 48/6 = 8 cycles. One has $(n_0, n_1, n_2) = (2, 12, 6)$.



Figure 8.2: $((n_0, n_1, n_2) = (4, 8, 8)$ Hamiltonian cycle with 2-fold rotational symmetry acting as 6-quint rotation.

There are therefore 5 different notions of harmony and they correspond to $n = \{6, 3, 5, 2, 1\}$ sub-harmonies. This gives altogether 6+3+5+2+1=17 different notions of harmony.

What is remarkable that the original candidate (3, 10, 7) for bio-harmony is not realized as a cycle possessing symmetries (it might be realized as one of the asymmetric cycles) but that there are at least three realizations for (4, 8, 8), which is forced by the condition that bio-harmony corresponds to the extended genetic code! The three (4, 8, 8) cycles are illustrated in **Figs. 8.1**, **8.2** and **8.3**.

8.6.3 Other Ideas

The book of Merrick discusses also other ideas. The attempts to understand music in TGD framework relate to these ideas.

p-Adic length scale hypothesis and music

One of the key ideas is the reduction of the octave phenomenon to the p-adic length scale hypothesis predicting that octaves and half-octaves correspond to p-adic scalings allowed by the hypothesis $p \simeq 2^k$ for the preferred values of the p-adic primes, and yielding scaled variants of physical systems. This idea will not be discussed in the following: suffice it to say that Pythagorean scale coming as powers of p = 3 strongly suggests approximate 3-adicity.

EEG and music

First of the key ideas relates to the idea that genetic code relates to the music scale.

- 1. Music metaphor is key element of TGD inspired view about biology and neuroscience. In particular, TGD based view about dark matter leads to the proposal that bio-photons are ordinary photons resulting as transformations of dark photons with large Planck constant $h_{eff} = nh$ to ordinary photons. The further hypothesis is that the energy spectrum of bio-photons is universal and contains visible photons and UV photons, which defined transition energies of biomolecules. This hypothesis follows if the value of h_{eff} assignable to a magnetic flux tube characterizes ion and is proportional to its mass number. The notion of gravitational Planck constant identified as $\hbar_{gr} = GMm/v_0$, where v_0 is a velocity parameter assignable to the two-particle system can be identified in the case of elementary particles and ions with h_{eff} and predicts also the universality of bio-photon spectrum.
- 2. In this framework bio-photons would represent music as light inducing molecular transitions. Notes that is different energies of bio-photons would correspond to different magnetic field



Figure 8.3: $((n_0, n_1, n_2) = (4, 8, 8)$ Hamiltonian cycle with 2-fold reflection symmetry acting as horizontal reflection.

strengths at magnetic flux tubes as was proposed much earlier in the quantum model of hearing [K102]. Could the biochemical and physiological aspects involved with the generation of music experience be realized in terms of bio-photon emission induced by the listening of music?

Standing waves and music

Merrick consider the idea that standing waves are essential for music experience. Preferred extremals of Kähler action representing standing waves does not seem to be feasible. The known preferred extremals (with "massless extremals" (MEs) included) would represent superpositions of Fourier components with four-wave-vectors which are proportional to each other. Essentially pulse propagating in fixed direction. For more general extremals this direction can depend on position.

Although standing waves are not feasible, effects which would be explained in Maxwell's theory in terms of standing waves are possible in many-sheeted space-time. A particle in a region of Minkowski space containing several space-time sheets touches all space-time sheets having non-vanishing Minkowski space projection to this region and the forced experience by it is sum of the forces caused by them. This leads to an operational defines of gravitational and gauge fields of Einstein-Maxwell limit of TGD as sum of the deviations of the induced metric from Minkowski metric and sum of the components of the induced spinor connection defining classical gauge potentials in TGD framework.

Test particles can clearly experience the presence of standing waves. It is enough to take two massless extremals with opposite directions of three momentum but same energy with nonempty projections to same M^4 region. Particle with experience standing wave oscillating with the frequency involved. The arrangements in which photons are taken to rest effectively could correspond to this kind of situations since if it is the motion of test particles which serves as a signature. Note however that there are also vacuum extremals for which the light velocity at the space-time surface corresponds to arbitrarily low velocity at the level of embedding space.

Emotions and 4-D character of music experience

Music experience involves in an essential manner time unlike visual experience which is essentially 3-dimensional. Music experience affects also emotions very directly. For instance, we somehow know the key of the piece and expect that it ends to the basic note and chord. We somehow know also the scale used (say major or minor) by the emotional response stimulated by it. All this requires information about entire time evolution of the music piece. The recent neuroscience based models of memory do not help much in attempts to understand how this is possible. The reason is that in the ordinary materialistic view in which the state of the brain at fixed time should determine the contents of consciousness.

The general vision in Zero Energy Ontology and Quantum Classical Correspondence is that space-time surface provide classical physics correlates for quantum states and also quantum jumps: the failure of the strict determinism is essential for the latter. The space-time surfaces are restricted inside causal diamond (CD) and have space-like 3-surface as their ends: the interpretation is as counterparts for the initial and final states of physical events.

The replacement of states with events makes it possible to understand mysterious looking facts about living matter such as standardized temporal patterns - say those appearing during morphogenesis. The maxima of the vacuum function defined by the exponent of Kähler function in term identified as Kähler action for Euclidian space-time regions representing analogs for the lines of Feynman graph correspond to the most probably temporal patterns.

The basic aspect of emotions is positive/negative dichotomy. An attractive identification for the physical correlated of this aspect is whether the quantum jump generating the emotion increases or decreases the negentropy of the subsystem involved. For instance, pain would correspond to a reduction of the negentropy for the body part involved. In music experience negentropy could flow between different parts of the system involved and create also sensation with local negative coloring but with overall positive coloring (by NMP [K80]). The ability of temporal patterns of music to generate negentropy flows inside the system involved could explain its effectiveness in generating emotions.

Dissonances were used by composes like Bach to generate melancholic emotions which suggests that the dissonance represent local reduction of negentropy. Also vibrato has emotional content. Physically dissonance and vibrato are assignable to the interference of frequencies which are near to each other (http://tinyurl.com/5r34ch). The basic formula is

$$\cos(x) + \cos(y) = \cos((x+y)/2) \times \cos((x-y)/2) \quad .$$

Acknowledgements: I want to thank Tommi Ullgren for directing my attention to the book of Richard Merrick as well as for fascinating discussions about music.

8.7 Water And Life

8.7.1 Latest View About Water Memory

The notion of water memory has several aspects. Water memory was introduced by Benveniste [I48, I49] to explain the claimed ability of homeopathically treated water to behave as if it contained the original molecules. Already Benveniste discovered the connection with very low frequency electromagnetic radiation and claimed that the patterns of this radiation carry the information about the molecule and represent its biologically relevant aspects. Water memory has been also assigned to the observation suggesting that the human intent has effect on the crystal structures formed as water near criticality freezes [L95, I30].

Basic aspects of water memory

The first aspect of water memory relates to homeopathy and is discussed from strongly skeptic point of view in Wikipedia article (see http://tinyurl.com/obvevp. Mae Wan-Ho (see http://tinyurl.com/29am8hz) takes a more balanced view on homeopathy in her article discussing the recent findings of the research group of HIV Nobelist Luc Montagnier providing strong support for water memory and suggesting also a connection with gene level [I60, I61].

The basic principle of homeopathy is "let like be cured by like". Homeopathic remedies are highly diluted preparations believed to cause in the healthy individuals effects similar to the undesired symptoms of the person treated. Homeopathy is not in accordance with the naïve materialistic beliefs about what water is (just the letters $H_2O!$) and what happens in succussion process producing the remedy. Not surprisingly, hard-nosed skeptics are not able to discuss the subject without bursts of rage. Obviously, the claimed effect of homeopathic remedy resembles that of vaccine and one might say that the harmful substance serves as its own antibody (see http: //tinyurl.com/7obde) eliminating the effect of the harmful substance. If one takes homeopathy seriously, the challenge is to explain this auto-antibody behavior. One can of course ask whether this behavior could in some sense be the basic mechanism of immune system.

In Benveniste's experiments [I48, I49] antibodies of human basophils were dissolved in water and the claim of experiments was that basophils added to the homeopathically treated water produced allergic reaction serving usually as a signature for the presence of antibody. As if water were able to mimic the antibodies in biologically relevant aspects. Later Benveniste was labeled as a fraud but the research has continued and it has been for long time thought that low frequency electromagnetic fields are essential for water memory. The frequencies in question extend to kHz range and cannot relate to molecular transitions. Cyclotron frequencies assignable to charged particles at the magnetic body of the molecule are the natural candidate in TGD framework.

Second aspect of water memory relates to the claim that human intent has an effect on the molecular structure of water. Clearly a special variant of remote mental interaction would be in question. Masaru Emoto [L95] has photographed water crystals resulting from water contained by a glass and subject to human intent. Depending on the origin of water the resulting water crystals can vary from random to very organized and aesthetic. Words, pictures, and music are used to generate the crystals. It is important to not forget that human intent is a decisive factor so that water need not be able to read as one especially simplistic and aggressive fanatic ridiculing Emoto claimed! Emoto has published several books containing pictures of the crystals and makes explicit that he is not a scientist but photographer who has discovered a fascinating new phenomenon and loves to document it.

Mae Wan-Ho has written an article titled "Crystal Clear - Messages from Water" (see http: //tinyurl.com/yjj9t4k) [L95] in which she discusses Emoto's work with intellectual honesty and giving primacy for facts instead of dogmas. The basic argument of skeptic is that water is just H_2O as we learned in school and therefore Emoto must be a swindler. The Wikipedia article (see http://tinyurl.com/dh4g6s) [I17] about Masaru Emoto's work represents a rather civilized skeptic reaction as compared to Harriet Hall's (see http://tinyurl.com/ot8zunw) piece of bad rhetorics filled with nasty ad hominem attacks. More ambitious skeptic believer bothers to develop an argument claiming that aesthetic appeal is highly subjective measure to characterize the water crystals. Here common sense and intellectual honesty clash with materialistic dogmas categorically denying this kind of effects, and the reader of these books must make a personal decision about what might be the truth - unless they decide to become photographers of water crystals.

The reader can also form his or her opinion about this aspect of water memory by looking the You tube video "Water has Memory" (see http://tinyurl.com/d7oto3d) [I30] prepared in Aerospace Institute in Stuttgart illustrating that the effect of human intent on the structure of water droplets is same for droplets from same source, is repeatable, and characterizes the operator. Also the effect of flowers dropped into the water is illustrated. All drops from a given source give rise to same structure characterizing the flower. It is suggested that water is a huge information source and serves as a kind of data medium. This proposal is highly trivial and would mean a profound modification of world view.

A simple model for water memory

Suppose that we just for a moment decide to overcome our intellectual laziness and are not satisfied with the standard rhetoric tricks of skeptics to convince ourselves that water memory researches must be swindlers or fools. In other words, we take the experimental evidence supporting water memory as something worth of considering seriously and try to build a model for the claimed phenomena. We can indeed imagine when we do not know. The challenge of the model for water memory is to explain the claimed basic aspects of water memory with minimal assumptions. Let us the restrict the model building further by assuming that we live in TGD Universe and that our vision about this Universe is roughly correct.

The ability of water molecule clusters to mimic the possibly harmful substances - call them just H - dissolved in water in some biologically relevant aspects could explain the effectiveness of homeopathic remedies. Water should make possible a symbolic representation of the molecules or their magnetic bodies.

1. Suppose H is a polar molecule so that it is biologically effective and that magnetic body characterizes the relevant biological effects of a polar molecule. Suppose that mechanical

agitation causes some polar molecules to lose their magnetic bodies so that they attach to water molecule clusters, which therefore become "actors" representing H. In the dilution the density of the fake molecules is also reduced but if the energy provided by shaking can be used as metabolic energy makes possible for the "actors" to replicate and their population can survive and even evolve in the sequence of "environmental catastrophes" induced by repeated succussions possibly also inducing evolution as an increase of Planck constant for the magnetic body of the "actor". Also the replication of the magnetic body of the "actor" is required. Cyclotron frequency spectrum would serve as a characterizer of molecule's magnetic body and cyclotron radiation would make possible communications between fake molecules and their magnetic body.

2. What the dropping of magnetic bodies really means? To answer the question consider a general vision about what happens as energy is fed into a system consisting of proteins dissolved in water. The proteins originally in closed globular configuration open as the ordered water covering their surfaces with "ice" melts. This leads to a protein aggregation (see http://tinyurl.com/yarrblxn) during the short "molecular summer" provided by the energy feed. The outcome is braiding and reconnection of flux tubes.

Suppose that this mechanism is at work also when proteins are replaced with harmful polar molecules. During "molecular summer" a reconnection process for closed loops emerging from water clusters and polar molecules would connect them with water clusters. Also the magnetic bodies of polar molecules would generate connections to water clusters via molecules. Self-reconnection for the flux tubes going through H molecules makes possible the transfer of the magnetic body of H to water molecule cluster. Water molecule cluster would "steal" the magnetic coat of H and H molecules would be left with short-cut closed flux tubes after the reconnection.

3. What is required that these water clusters or something associated with them can replicate and develop to a population representing the original molecules. The needed metabolic energy would come from mechanical agitation. Note that this replication should involve also the replication of magnetic bodies which suggests that linear structures generating planar flux tubes emanating from the basic building bricks of the structure are involved. This will be discussed below.

What could then be the healing mechanism in homeopathy? Why the presence of the fake molecules in organism would prevent the harmful actions of real molecules in the organism? What could be the translation of "Let like be cured by like" to the language of quantum TGD?

- 1. Suppose that the effects of H on bio-molecules are due to cyclotron radiation along the flux tubes of its magnetic body connecting it to bio-molecules of the organism. Suppose that the fake representatives of H contained by the homeopathic remedy and real molecules Hreconnect so that the flux loops associated with H and fake H reconnect to a pair of flux tubes connecting H and fake H. Suppose that this happens with such high a rate that the fraction of the connections to other biomolecules remains low.
- 2. If so, fake H would effectively act antibody of H and the effects of H via its magnetic body on organism would be minimized. Like would indeed cure like. Could this reconnection mechanism be at work also when antibody attaches to the harmful molecule? If so, the basic mechanism of immunization would be universal and involved the notion of magnetic manner in an essential manner.

Dark nucleon genetic code as realization of water memory, and homeopathic mechanism as basic mechanism of immune system

The proposal says nothing about the detailed structure of water clusters, and does not mention dark nucleons nor the proposal for the realization of genetic code based on them. A more refined model would include also these and give a connection for how immune system would utilize the reconnection of flux tubes defining the basic mechanism of homeopathy.

- 1. TGD predicts a realization of vertebrate genetic code at the level of dark nucleons. Dark nucleons correspond to the states of DNA, RNA, tRNA, and amino-acids and represent vertebrate genetic code under rather general assumptions [L3]. One could even consider the extension of the genetic code to a naming of polar molecules by sequences of representatives of DNA letters. Suppose that dark proton sequences are attached to a polar molecule dissolved in water, and define a representation of the molecule in terms of code letters realized as exotic protons with Compton length in nano-scale. The assignment of the magnetic body of the molecule to water cluster would give it the same "name" as for the original molecule. It is of course possible to have other representation and one of them would be in terms of dark u quarks providing representation of A, T, C, G in terms of spin states.
- 2. If the population of dark DNA molecules assigned with the harmful substance H is able to use the energy provided by the succussion process as a metabolic energy for replication, the disappearance of H is compensated by the replication of dark DNA representing it. Dark DNA becomes the representative of H. The growing population would consist of dark DNA and the flux tubes of the magnetic body connect to dark DNA strands. Replication would be the analog of that for ordinary DNA and involve also the replication of magnetic bodies. The water would contain pairs of dark DNA and its conjugate connected by a flux tube and these flux tubes would reconnect with flux tubes connecting the dark DNA sequence representing H and connected by flux tubes to its conjugate.
- 3. It is known that the DNA of the immune system evolves with an especially high rate. Could the universal naming mechanism allow the immune system to generate new immune responses via the transcription of the dark DNA sequence representing the harmful molecule to a real DNA, which in turn codes for amino-acid attaching to the harmful molecules along the dark nucleon sequence? A model for homeopathy would extend to a model for the functioning of immune system. This would be of course also a mechanism of evolution as a reaction to changing chemical environment. This would explain also the effect of the homeopathic remedy as an effect at gene level.

It is difficult to exaggerate the potential significance of this mechanism for biology, genetic engineering, and medicine. Understanding of the contemptible homeopathy could induce decisive step in the understanding of biology. This possibility shows how dangerous it is to take the claims forced by a particular belief system like materialism as final truths.

Reader has certainly noticed that reconnection mechanism pops up again and again in the model and would be also the fundamental mechanism of ordinary DNA replication, transcription, translation of mRNA to proteins, and of process catching tRNA molecules carrying amino-acids to form protein at mRNA. This mechanism would be realized even in the mutual interactions between living organisms and between living organisms and inanimate matter.

Braiding represents as a higher level aspect of water memory

Braiding represents another aspect of water memory relating to the representation as dark nucleon sequences as the quantum computer programs represented by braidings to DNA in the model of DNA as topological quantum computer [K6]. The memories represented by braiding would be about the flow of water and molecules rather than about substances present in the water. The model of qualia [K59] is based on flux tube connections between system representing self and environment. For polar molecules the qualia would relate to charge and electric polarization. Could the qualia assignable to polar molecule plus environment have scaled down fractal variants at the level of water clusters of environment? If this were the case then water would effectively produce representations about molecule at the level of qualia. Could also these relate to water memory?

Effects of intent on water crystallization

One should understand the effect of intent on water in terms of water memory. The proposed representation of polar molecules in terms of dark DNA sequences is one possible realization of water memory reducing naming of molecules to genetic code letters. Essentially addressing of molecules would be in question. This aspect of water memory is not relevant now. Rather, what matters is the interaction of water with human operator and reconnection of flux tubes of magnetic bodies is a good guess for how this interaction is realized. The same mechanism is involved also with the interaction of homeopathic remedy and harmful substance.

How could one understand the effect of intent on water crystallization, which characterizes the operator involved. The situation would be very much like that in the experiments of Tiller [J110]. The magnetic bodies assignable to the operator and water must interact and produce the effects. This would not be surprising if similar interaction takes place in the case of dissolved substances.

A concrete model for the interaction would be in terms of the reconnections of closed flux tubes emerging from the biological body of subject person with the flux tubes of the magnetic body of water creating direct flux tube contacts between the two bodies. The presence of magnetic flux tube connections between water sample and operator's magnetic and biological body would induce the effects on crystallization of water. Water memory should be stable in human time scales. This requires that these flux tube patterns are rather stable modification of the magnetic body of water. Large values of Planck constant assignable to the magnetic body of human agent would be needed. What is required is that the crystallization patterns and therefore structures of water clusters correlate with the structure of the magnetic body of the water sample.

Magnetic body and migrating birds

What happens when the water glass in the experiments of Emoto is taken to a large distance from operator? Does the effect prevail? If the magnetic flux tubes stretch, this interaction need not cease as the distance between operator and water glass increases unless the double flux tube splits by self-reconnection. If so, water could indeed act as a data medium as proposed in the video about water memory.

Magnetic body could play key role in understanding how birds and fish manage to find their birth places during migration is one of the many unresolved mysteries of biology. It has been suggested that orienteering in magnetic field of Earth using neuron level compass is in question but this proposal has its difficulties. Could it be that the birds and fish are connected by the magnetic flux tubes of their personal magnetic body or of that of the species to the birth place so that they would only follow Ariadne's thread?

8.7.2 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) [I60].

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 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 [K105]. 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 his. 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 mumetal between the tubes. Emission of similar signals was observed for many other bacterial specials, 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 300 μ [I41] provides experimental support for the notion.

- If the matter at given layer of the onion-like structure formed by magnetic bodies has large ħ, 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 [K6]. 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 the 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 correspond 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 [L32] [K102] (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.

8.7.3 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" [D22] and "Making Fuel from Water" [D20]. The articles summarize an experimental discovery which could be called Pollack-Zheng effect [D27, D23]. 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 [K17, K68]. 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 [I44] : 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 [D22].

Exclusion zones

The article summarizes the sequence of events initiated by the discovery of Gerald Pollack and his student Jian-ming Zheng [D27, D23]. 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 precedessors. Pollack and coauthors have indeed proposed that their finding might relate to the origin of life [D23]. 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 [K10].

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 (T2) 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 precedessor 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 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 served as one motivation for the original $\hbar/\hbar_0 = 2^{11k}$ hypothesis for the preferred values of Planck constant. 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 ($\simeq 5 \text{ eV}$) 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 [K6]. 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 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 h_{eff} so that cyclotron energy would be liberated.

- 2. The findings suggest also a mechanism for how solar radiation generates proto cells or their precedessors. 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 [K6]. 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 [K26]. Cell membrane acts as a Josephson junction in TGD based model of cell membrane, nerve pulse, and EEG.

8.7.4 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 [I134]. This suggests a connection with Pollack-Zheng effect [D27]. 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 biomolecules in the internal electric field of the molecule or dark protons of water molecules in the electric field induced by Pollack-Zheng effect [D27] 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 aminocids 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 .

8.8 New findings related to the chiral selection

I learned of very interesting empirical findings related to the chiral selection of biomolecules (see the popular article). The article "Enantioselective Adsorption on Magnetic Surfaces" of Mohammad Reza Safari et al [?] is published in the journal Advanced Materials (2023).

8.8.1 The findings

Consider first the experimental arrangement and findings.

- 1. There is a copper conductor with a strong electric field in the normal direction of the conductor. Cu is not a magnetic substance. There are very thin Cobalt islands at the surface of the conductor. Cobalt is a magnetic metal. There are two options: magnetization direction is North or South and it corresponds to either up or down. North up and South down are the options and these could correspond to different chiralities somehow.
- 2. The molecules drift to the Cobalt islands and, depending on their chirality, prefer to bind to either south-up or north-up Cobalt islands. Are the magnetic fields of islands helical and possess a definite chirality? Does the magnetic chirality tend to be the same or opposite to that of the enantiomer that binds to it?
- 3. The effect is reported to occur already before the Cobalt islands in the drifting of molecules to the Cobalt islands. What does this mean? Counterparts of magnetic fields are not present.
- 4. It is also found that electrons with a given spin direction prefer to tunnel through the molecules in a direction which correlates with the chirality.

8.8.2 TGD view of the findings

These are highly interesting findings providing new empirical hints about the nature of chiral selection in living matter. Weak interactions are really weak and parity violation effects should be extremely small above weak scale so that the standard model fails to explain chiral selection.

TGD view of dark matter and chiral selection

The TGD view of dark matter would make possible chiral selection.

- 1. Chiral selection is one of the key empirical facts supporting the TGD prediction of a hierarchy of phases of ordinary matter predicted by the number theoretical vision of TGD [L107, L70, L165, L136, L138, L147]. These phases are labelled by effective Planck constant h_{eff} , which is essentially the dimension of an algebraic extension of rationals.
- 2. The predicted huge values of h_{eff} assignable to classical gravitational and electric fields of astrophysical objects [L147] mean that weak interactions become as strong as em interactions below the scale up Compton length of weak bosons, which, being proportional to h_{eff} , can be as large as cell size. This amplifies parity violation effects visible for instance in hydrodynamics [K2].
- 3. Large h_{eff} phases behave like dark matter: they do not however explain galactic dark matter, which in the TGD framework is dark energy assignable to cosmic strings (no halo and an automatic prediction of the flat velocity spectrum). Instead, large h_{eff} phases solve the missing baryon problem [L161]. The density of baryons has decreased in cosmic evolution (having biological evolution as a particular aspect) and the explanation is that evolution as unavoidable increase of algebraic complexity measured by h_{eff} has transformed them to $h_{eff} \ge h$ phases at the magnetic bodies (thickened cosmic string world sheets, 4-D objects), in particular those involved with living matter.
- 4. The large value of h_{eff} has, besides number theoretical interpretation [L160], a geometric interpretation. Space-time surface can be regarded as manys-sheeted over both M^4 and CP_2 . In the first case the CP_2 coordinates are many-valued functions of M^4 coordinates. In the latter case M^4 coordinates are many-valued functions of CP_2 coordinates. This case is highly interesting in the case of quantum biology. Since a connected space-time surface defines the quantum coherence region, an ensemble of, say, monopole flux tubes can define a quantum coherent region in the latter case: one simply has an analog of Bose-Einstein condensate of monopole flux tubes.

The flux tube condensate as a covering of CP_2 means a dramatic deviation from the QFT picture and is a central notion in the applications of quantum TGD to biology. Therefore some examples are in order.

- 1. Fermi liquid description of electrons relies on the notion of a quasiparticle as an electron plus excitations of various kinds created by its propagation in the lattice. In some systems this description fails and these systems would. have a natural description in terms of space-time surfaces which are multiple coverings of CP_2 , say flux tube condensates.
- 2. In high Tc superconductors and bio-superconductors [K100, K101] the space-time surface could correspond to this kind of flux tube condensates and Cooper pairs would be fermion pairs with members at separate flux tubes. The connectedness of the space-time surface having about $h_{eff}/h = n$ flux tubes would correlate the fermions.
- 3. Bogoliubov quasiparticles related to superconductors are regarded as superpositions of electron excitation and hole. The problem is that they have an ill-defined fermion number. In TGD, they would correspond to superpositions of a dark electron accompanied by a hole which it has left behind and therefore having a well-defined fermion number. Bogoliubov quasiparticle is indeed what can be seen using the existing experimental tools and physical understanding.
- 4. Strange metals would be an example of a system having no description using quasiparticles, as the linear dependence of the resistance at low temperatures demonstrates. I have considered a description of them in terms of Cooper pairs at short closed flux tubes [K100, K118]: this would however suggest a vanishing resistance in an ideal situation. Something seems to go wrong.

An alternative description could be in terms of superpositions of dark electrons and holes assignable to the flux tube condensate. Strange metal is between Fermi liquid and superconductor: this conforms with the fact that strange metals are quantum critical systems. The transition to high Tc superconductivity is preceded by a transition to a phase in which something resembling Cooper pairs is present.

A natural looking interpretation would be in terms of a flux tube condensate and pairs of dark and ordinary electrons. Also now the flux tubes could be short. In [K33], I have considered the possibility that high Tc superconductors could be this kind of "half-superconductors" but this option seems to be wrong.

The phase transitions between "half-superconductivity" and superconductivity could play a central rol also in living matter.

A more detailed view of chiral selection in the TGD framework

Before proceeding to a detailed model, one must understand how the large parity violation required by the chiral selection could emerge in the TGD framework.

1. Since the Kähler action does not contain the induced $SU(2)_L$ weak fields, there should be no direct parity violation at the space-time level. The geometric parity violation as a chiral selection of bio-molecules could be however induced from the fermionic dynamics induced by the modified Dirac action determined completely the bosonic action. The twistor lift of TGD [K132, L76, K16] suggest that this action is a sum of volume term and Kähler action.

Holography realized as generalized holomorphy implies that solutions are minimal surfaces irrespective of action and only the conditions at boundaries and singularities distinguish between different general coordinate invariant actions constructible using the induced geometry.

2. In the standard physics framework one could argue that Chern-Simons term relates to the parity violation. Now the situation is not so straightforward since parity violation for the weak interactions basically occurs at the level of $M^4 \times CP_2$ and is induced to the space-time level.

Chern-Simons-Kähler (CSK) action emerges from the topological istanton term $J \wedge J$ in the exponent defining vacuum functional [K65, K109, L158, K144]. The CSK term is naturally imaginary whereas the non-topological term defining the Kähler function as Kähler action would be real. The CSK term contains two parts corresponding to M^4 and CP_2 parts of the Kähler form. Neither Kähler action nor CSK action contain the induced $SU(2)_L$ gauge potentials so that parity violation directly induced by weak interactions is not present. CSK action is associated with partonic orbits carrying fermion lines identified as the lightlike boundaries of the space-time surface and the interfaces of Euclidean and Minkowskian regions of the space-time surface.

3. CSK term contributes also a term to the modified Dirac action [K144] [L162], which is fixed completely by the bosonic action defining the space-time surfaces as a Bohr orbit-like preferred extremals satisfying holography, which reduces to a generalized holomorphy [L158].

What is crucial is that the covariant derivative acting on the induced spinor fields, obtained by restricting the second quantized H spinor fields to the space-time surface, contains the parity violation weak interaction term so that the parity violation at the level of elementary fermions emerges through it. This parity violation must induce the geometric parity violation at the level of the geometry of space-time surfaces distinguishing between different chiralities in dark weak scales.

4. The model of anomalous electron-positron pairs produced in heavy nucleus collisions [K136] assigns dark leptopion condensate to the non-vanishing of the Chern-Simons term requiring that the induced Kähler and electric fields are not orthogonal. The condition that the dark leptopion Compton wavelength, which is 1/2 of dark electron Compton length, should be of the order of the thickness of the electric flux tube. One must assume that the leptopions are dark in the sense that they have $h_{eff} \neq h$ since otherwise they would be produced in the decays of weak bosons.

It will be found that the model provides further support for a generalization of the Pollack effect [I83, L36, I137, I115]: instead of protons of water molecules, electrons at the conductor surface would be transformed to dark electrons at the magnetic monopole flux tubes. This suggests also a generalization [L138] of the dark genetic code [L97, ?, L128, L145]. For this generalization dark proton triplets as a representation of codons would be replaced with dark electron triplets. The universality of the realization of the dark genetic code in terms of the completely unique icosa tetrahedral tessellation of hyperbolic space H^3 supports this idea.

8.8.3 A TGD based model for the findings

Consider now a concrete model for the findings in the TGD framework.

- 1. A good guess is that the molecular monopole flux tubes of the molecules and of the magnetic fields assignable with the Cobalt islands tend to have the same chirality. This would generalize the chiral selection from the level of biomolecules to the level of dark monopole flux tubes. Some kind of condensate of flux tubes of the same chirality as a long scale parity violation would be in question.
- 2. In the TGD framework, the North up and South up magnetic fields could correspond to helical monopole flux tubes of opposite chiralities. The helical structure is essential and could relate directly to the requirement that the flux tube is closed: one could have a shape of flattened square for which the long sides form a double helix. This would be the case also for DNA.
- 3. Parity violation requires a large value of h_{eff} . Dark Z (and W) bosons could generate a large parity violation. Dark Z boson Compton length of order biological scale. The very large value of h_{eff} would give the needed large energy splitting between generalized cyclotron energies at the dark flux tube and induce chiral selection.

Gravitational flux tubes of the Earth's gravitational field or solar gravitational field would do the job. By the Equivalence Principle, the gravitational Compton length $\Lambda_{gr,E} = .5$ cm for Earth does not depend on the particle mass and looks like a promising scale. Also the cyclotron energies are independent of the mass of the charged particle since \hbar_{gr} is proportional to particle mass m and cyclotron frequency to 1/m.

4. Also the electric field of the Copper surface should have an important role. The electric field orthogonal to Cu conductor would correspond to electric flux tubes. The consistency condition for the electric flux tube thickness with charged at the bottom (conductor) reads as $\Lambda_{em}(d) \sim d$. $\hbar_{em} = Ne^2/\beta_0$, N the number of electrons at the bottom. There is roughly one electron per atom. $N \sim 10^4$ per flux tube area of 100 nm² having radius about 10 nm. $\Lambda_{em} = Ne^2/\beta_0 \lambda_e$ is about 1 nm for $\beta_0 = 1$. The value of \hbar_{em} are rather small and it seems that it cannot contribute to the chiral selection. One can however consider also the electric field of Earth, and in this case the situation could be different.

The effect occurs already before the Cobalt islands. Furthermore, electrons with a given spin direction prefer to tunnel through the molecules in a direction dicrated by the chirality. What could this mean?

- 1. The counterparts of magnetic fields are present as dark magnetic fields inside the magnetic bodies of the drifting molecules. Suppose that dark molecular gravitational monopole tubes are indeed present and give rise to closed spin current loops with a direction determined by the chirality of the molecule. This would give rise to the large parity violation but how to understand the occurrence of the effect already before the Cobalt islands?
- 2. Could one assign a definite chirality also to the electric flux tubes assignable to the Cu surface and assume that the molecular chirality tends to be the same (or opposite) to this chirality? Do also these closed monopole flux tubes carry dark electric current?

The spin direction of the current carrying electrons would correlate with the magnetization direction so that the magnetic body of the molecule would prefer a pairing with the electric body with a preferred spin direction. The preferred pairing would explain the drift to a correct Cobalt island: the paths leading to the Cobalt island would be more probable.

3. In the case of water, the Pollack effect [I83, L36, I137, I115] transfers part of the protons of water molecules to dark protons at monopole flux tubes. Now there are no protons available.

Does this require a generalization of the Pollack effect? Could the electric flux tubes be gravitational flux tubes carrying electrons instead of protons? Gravitational Compton length would be the same. Could electronic Pollack effect for conductors as a dual of Pollack effect for water be in question.

4. In the TGD inspired quantum biology, one assigns genetic code with dark proton triplets. Could one assign a dark realization of the genetic code to dark electron triplets? Could the electric counterparts of gravitational flux tubes carrying dark realization of the genetic code define dark genetic code? Codons would correspond to dark electron triplets instead of dark proton triplets. Could the analogs of the ordinary genetic codons correspond to the triplets of electron holes at the conductor surface?

The TGD based vision about universal genetic code suggests the existence of a 2-D analog of DNA realized in terms of mathematically completely unique hyperbolic icosa tetrahedral tessellation. Could this genetic code be associated with the metal surfaces? The implications of this hidden genetic code for computers might be rather dramatic.

8.8.4 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 [D22, D20, D18, D21] 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" [D22] told about the formation of exclusion zones around hydrophilic surfaces, typically gels in the experiments considered [D27]. 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 suggests only few molecular layers instead of millions. Sunlight induced the effect. This finding allow 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?" [D18] 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 [D1]. The mystery is of course how so low frequency can induce burning. The article "The body does burn water" [D21] 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 [D19]. As a matter 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 [D20]. 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 [K68].

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 [D17, D16, D24, D13]. 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 [D1]: 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?" [D18] provides new information about burning salt water [D1], 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) [I54], and that even a realization of genetic code in terms of the time variation of polarization direction could be involved. TGD based model [K24, K135] 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 [D5]. 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 [D4] - 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 ealier 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 h_{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 [H8] 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 [K69] 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, t 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.

8.8.5 How Bio-Polymers Were Associated With Their Dark Counterparts?

The experiments of Pollack [L36] demonstrating what he calls fourth phase of water is characterized by negatively charged regions - exclusion zones (EZs). The stoichiometry of water inside EZ is $H_{1.5}O$. TGD based model assumes that part of protons in these regions have been transferred to magnetic flux tubes were they form sequences identifiable as dark nuclei. The surprising finding is that a simple model for dark proton allows to assign its states to multiplets for which numbers of states are those assignable to DNA, RNA, and tRNA codons, plus amino-acids. Also the vertebrate genetic code can be realized in a simple manner. This leads to a vision about prebiotic life as dark life evolved in water before the ordinary life. Dark life would be present also in ordinary life forms.

If one believes that dark proton sequences [K62] define the counterparts of DNA, RNA, tRNA, and amino-acids realized at magnetic flux tubes, the question is how this form of life was transformed to the bio-chemical life.

The article "Hydrogen cyanide polymers, comets and the origin of life" (http://tinyurl. com/ybfuwneq, thanks to Ulla for the link) helped me to discover a new big gap in my knowledge about biology and this in turn led to a more detailed vision about how the transition could have taken place. HCN is everywhere and Miller demonstrated in his classic experiments that 11 out of 20 amino-acids emerged in presence of HCN. It has been later found that well over 20 amino-acids were produced. (http://tinyurl.com/y9at46fe). In my own belief system amino-acids could have appeared first as concrete something "real" and DNA as symbolic representations of this something "real". First at dark matter level and then biochemically.

In TGD Universe one can imagine - with inspiration coming partially from Pollack's experiments [L36] (http://tinyurl.com/oyhstc2) - that dark variants DNA, RNA and amino-acids were realized first as dark proton sequences at flux tubes- dark nuclei - I call them just dark DNA, RNA and amino-acids although dark proton sequences are in question. The genetic machinery involving translation and transcription was realized as dark variant and dark DNA was a symbolic representation for dark amino-acids.

How did this dark life give rise to bio-chemical life as its image? This is the question! I can only imagine some further questions.

- 1. Was this process like master teaching to a student a skill? Master does it first, and then student mimics. If so, the emergence of amino-acids, mRNA and DNA polymers would *not* have been purely chemical process. Dark variants of these polymers would have served as templates for the formation of ordinary basic biopolymers, for transcription, and for translation. These templates might have been necessary in order to generate long RNA and DNA sequences: mere chemistry might have not been able to achieve this. Without dark polymers one obtains only bio-monomers, with dark polymers as template one obtains also bio-polymers. Dark polymers would have been the plan, biopolymers the stuff used to build.
- 2. Are dark DNA, RNA, amino-acids, etc indeed still there and form binary structures with their biochemical variants as I have indeed proposed?
- 3. Are dark translation and transcription processes still an essential part of ordinary translation and transcription? Master-student metaphor suggest that these dark processes actually induce them just like replication of magnetic body could induce the replication of DNA or cell. Visible chemistry would only make visible the deeper "dark chemistry". Apologies for all biochemists who have done heroic work in revealing chemical reaction paths!

How the process assigning biochemical life to dark life could have proceeded? The minimalistic guess is that the only thing that happened was that dark life made itself gradually visible! As a consciousness theoretician I have a temptation to see religious statements as hidden metaphors, at least they provide an excellent manner to irritate skeptics: Dark matter - the "God" made usthe biological life - to its own image.

- 1. First dark amino-acid sequences were accompanied by ordinary amino-acid sequences so that the dark translation process had now a visible outcome. At this step the presence of HCN was crucial and made the step unavoidable. Also the presence of template was necessary.
- 2. Dark mRNA got a visible counterpart in the same manner: the presence of template made possible long RNA polymers. The translation remained basically dark process but made visible by mRNA.
- 3. Dark DNA got a visible companion: again the presence of the template was and still is crucial.

What about generation of DNA and RNA? It is known that in reducing atmosphere DNA and RNA nucleobasis are obtained in an environment believed to mimick prebiotic situation: the presence of HCN and ammonia are necessary (http://tinyurl.com/y9at46fe). Reducing atmosphere http://tinyurl.com/yc62g22f does not oxidize, in other worlds does not contain oxygen and other oxidizing agents and can contain also actively reducing agents such as hydrogen, carbon monoxide. There are however some problems.

- 1. There is evidence that early Earth atmosphere contained less reducing molecules than thought in times of Miller. If life emerged in the underground water reservoirs as TGD strongly suggests, the usual atmosphere was absent and there are good hopes about reducing atmosphere.
- 2. The experiments using reducing gases besides those used in Miller's experiments produce both left and right handed polymers so that chiral selection is missing. This is not a surprise since weak interactions generate extremely small parity breaking for visible matter. If dark proton strings or even dark nuclei are involved, the Compton length of weak gauge bosons can be of the order of atomic length scale or even longer and weak interactions would be as strong as electromagnetic interactions. Therefore chiral selection becomes possible. The simplest option is that chirality selection occurred already for the helical magnetic flux tubes and induced that of biopolymers.

8.9 Water Memory And Pre-Biotic Life

Pollack's findings [L36] discussed from TGD view point in [K101, K97] provide new insights to the mechanisms of water memory and homeopathy. Also the attempts to understand the dependence of h_{eff} on parameters of the system involved provide help. This picture also suggests a more detailed vision about prebiotic life forms as analogs of exclusion zones involving charge separation leading to large value of h_{eff} .

8.9.1 Exclusion Zones As Prebiotic Cells

TGD based model model [L36], [K98] for Pollack's findings [L36] 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 μ 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, K62].
- 6. Negatively charged EZ could define a pre-biotic cell so that water would be a primitive prebiotic 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.

8.9.2 TGD View About Homeopathy, Water Memory, And Evolution Of Immune System

The following gives an attempt to build a brief sketch of TGD based model of water memory and homeopathy as it is after the input from Pollack's findings and $h_{eff} = h_{gr} = h_{em}$ hypothesis.

Summary of the basic facts and overall view

A concice summary of the basic qualitative facts about homeopathy [K62] could be following.

- 1. The manufacture of the homeopathic remedies consists of repeated dilution and agitation of water sample containing the molecules causing the effect which the remedy is intended to heal. This paradoxical looking healing method is based on "Alike likes alike" rule. This rules brings in mind vaccination causing immune system to develop resistance. The procedure seems to somehow store information about the presence of the molecules and this information induces immune response. Usually it is the organisms or molecules causing the disease which induce immune response.
- 2. The ultra-naïve and simplistic objection of skeptic is that the repeated dilution involved with the preparation of homeopathic remedy implies that the density of molecules is so small that the molecules can have absolutely no effect. Despite the fact that we live in information society, this is still the standard reaction of a typical skeptic.
- 3. A lot of research is done by starting from the natural idea that the electro-magnetic fields associated with the invader molecules (or more complex objects) represent the needed information and that water somehow gets imprinted by these fields. This could for instance mean that water clusters learn to reproduce radiation at frequencies characterizing the invader molecule. Benveniste is one of the most outstanding pioneers in the field [I48]. Benveniste *et al* [I49] even managed to record the VLF frequency finger print of some bio-active molecules and record them in binary form allowing to to yield the same effect as the real bio-active molecule induced. Benveniste was labelled as a fraud. The procedure used by the journal Nature to decide whether Benveniste is swindler or not brings in mind the times of inquisition. It tells a lot about attitudes of skeptics that magician Randi was one member of the jury!

4. Benveniste's work has been continued and recently HIV Nobelist Montagnier produced what might be regarded as remote replication of DNA using method very similar to that used in manufacturing homeopathic remedy [I60, I61].

The general conclusion is that the em frequencies possibly providing a representation of the molecules are rather low - in VLF region - so that frequencies assignable to molecular transitions are not in question. Cyclotron frequencies assignable to the molecules are the most natural candidates concerning physical interpretation. The corresponding photon energies are extremely low if calculated from E = hf formula of standard quantum mechanics so that quantal effects in the framework of standard quantum theory do not seem to be possible.

My personal interest on water memory was sparked by the work of Cyril Smith [J21]. What I learned was what might be called scaling law of homeopathy [K62]. Somehow low frequency radiation seems to be transformed to high frequency radiation and the ratio $f_h/f_l \simeq 2 \times 10^{11}$ seems to be favored frequency ratio.

These two basic findings suggest what looks now a rather obvious approach to homeopathy in TGD framework. The basic physical objects are the magnetic bodies of the invader molecule and water molecule cluster or whatever it is what mimics the invader molecule. The information about magnetic body is represented by dark cyclotron radiation generated by the invader with frequency f_l . This dark radiation is transformed to ordinary photons with frequency f_h and energy $h_{eff}f_l = hf_h$, which is above thermal energy, most naturally in the range of bio-photon energies so that the radiation can directly induce transitions of bio-molecules. The analogs for the EZs discovered by Pollack are obvious candidates for "water molecule clusters".

The following summarizes this overall picture in more detail.

Dark photon-bio-photon connection

The idea that bio-photons are decay product of dark photons emerged from the model of EEG [K48] in terms of dark photons with energies above thermal energy. Dark photons in question would be emitted as cyclotron radiation by various particles and molecules, perhaps even macromolecules like DNA sequencies. Also cell membrane would emit dark photons with frequencies, which correspond in good approximation to differences of cyclotron energies for large value of $h_{eff} = nh$ [K101, K48].

- 1. Bio-photons have spectrum in the visible and UV would decay products of dark cyclotron photons. If the h_{eff} of particle is proportional to its mass then the cyclotron energy spectrum is universal and does not depend on the mass of the particle at all. The original model of EEG achieved this by assuming that h_{eff} is proportional to the mass number of the atomic nucleus associated with the ion.
- 2. The ideas about dark matter involve two threads: $h_{eff} = n \times h$ thread motivated by biology and the thread based on the notion of gravitational Planck constant and inspired by the observation that planetary orbits seem to obey Bohr rules. $\hbar_{gr} = GMm/v_0$ is assigned to the pairs of gravimagnetic flux tubes and massless extremals making possible propagation of dark gravitons. The realization was the two threads can be combined to single thread: by Equivalence Principle h_{gr} hypothesis is needed only for microscopic objects and in this case $h_{eff} = h_{gr}$ makes sense and predicts that dark photon energies and dark particle Compton lengths do not depend on particle and that bio-photon energy spectrum is universal and in the desired range if one assumes that h_{gr} is associated with particle Earth par with v_0 the rotational velocity at the surface of Earth. Even $h_{eff} = h_{em} = h_{gr}$ hypothesis makes sense. $h_{em} = h_{gr}$ is also very natural assumption for ATP synthase which can be regarded as a molecular motor whose rotation velocity appears in the formula for h_{em} .
- 3. The prediction would be that any charged system connected to Earth by flux tubes generates cyclotron dark photons decaying to bio-photons. Bio-photons in turn induce transitions in biomolecules because the energy range is in visible and UV. Magnetic bodies can control biochemistry via resonant coupling with bio-photons.

Molecular recognition mechanism as basic building brick of primitive immune system

The reconnection of U-shaped magnetic flux tubes emanating from a system makes possible a recognition mechanism involving besides reconnection also resonant interaction via cyclotron radiation which can induced also biochemical transitions of $h_{eff} = h_{gr}$ hypothesis holds true.

- 1. Molecules have U-shaped flux tube loops with fluxes going in opposite directions. This makes possible also super-conductivity with members of Cooper pair at the parallel flux tubes carrying magnetic fluxes in opposite direction since magnetic fields now stabilize Cooper pairs rather than tend to destroy them.
- 2. The flux loops associated with systems call them A and B can reconnect and this leads to the formation of 2 parallel flux tubes connecting A and B. Stable reconnection suggests that magnetic field strengths must be same at the flux tube pairs associated with A and B. This implies same cyclotron frequencies and resonant interaction. This would define molecular mechanism of recognition and sensing the presence of invader molecules even conscious directed attention might be involved.
- 3. Systems with magnetic body could be constantly varying the thicknesses of at least some of their flux tubes and in order to reconnect with the magnetic body of a possible invader. This activity could be behind the evolution of the immune system.

The question is how the system or its sub-system could stabilize itself so that it would receive signals only from one kind of molecule specified by its cyclotron frequency spectrum.

1. If the flux tubes carry monopole flux (this is possible in TGD framework and requires the flux tube cross section is closed 2-surface), stabilization of the flux tube thickness stabilizes the magnetic field strength. How the stabilization of the thickness of the flux tubes could have been achieved?

Pollack's negatively charged EZs with dark protons at magnetic flux tubes giving rise to dark nuclei identifiable as dark proton sequences suggests an answer. Maybe the presence of dark proton sequences could stabilize the flux tube thickness. Dark proton sequences have also interpretation as dark DNA/RNA/amino-acid sequences [L3].

A further question is whether the magnetic body of the prebiotic cell identified as EZ could use the information about invader molecule to represent its magnetic body either concretely and perhaps even symbolically and regenerate the concrete representation when needed.

- 1. The concrete representation could be in terms of dark proteins whose folding would represent the topology of the invader molecule and symbolic representation in terms of dark DNA transcribed to dark protein. If the dark protein has same topology of knotting it could more easily attach to the invader molecule and make it harmless. Note that the invaders are naturally other dark DNAs and proteins jus as in living matter. The higher purpose behind this cold war would be stimulation of mimicry - emulation in computer science - leading to generation of cognitive representations and negentropic entanglement.
- 2. Not only the representation of the 3-D magnetic body its behavior is possible. In ZEO also the representation of the dynamical evolution of magnetic body becomes possible since basic objects are pairs of 3-surfaces at future and past boundaries of causal diamond. The challenge is to represent the topology time development of magnetic body 2-braiding, first concretely by mimicking it and then symbolically in terms of DNA coding for proteins doing the mimicry. The obvious representation for the behavior of magnetic body of invader molecule would be in terms of folding and unfolding of protein representing it.
- 3. The question how the symbolic representation could have emerged leads to a vision about how genetic code emerged. The model for living system as topological quantum computer utilizing 2-braiding for string world sheets at 4-D space-time leads to the idea that 3-D coordinate grids formed by flux tubes are central for TQC: each node of grid is characterized by 6 bits telling about the topology of the node concerning 2-braiding. Could the 6 bits of dark DNA code for the local topology of the invader molecule and an the flux tube complex mimicking it?

4. This raises the possibility that DNA strands - one for each coordinate line in say z-direction could code for the 2-braiding of 3-D coordinate grid and in this manner code for the magnetic template of invader molecule and also that of the biological body. Therefore genetic code would code for both the basic building bricks of the biological body and 4-D magnetic body serving as template for the development of biological body.

One can imagine how the biochemical evolution after this stage might have taken place.

- 1. At the next step the chemical representation of genetic code would have emerged. Dark proteins learned to attach to real proteins and real proteins to other proteins and DNA and bio-catalysis became possible.
- 2. The transformation of the ordinary photons emitted in the transitions of biomolecules to dark photons made possible the recognition of invader molecules using ordinary photons emitted in their molecular transitions.
- 3. Magnetic bodies learned to control biochemical reactions by using dark cyclotron radiation transformed to bio-photons.
- 4. Gradually dark and ordinary proteins developed a rich repertoire of functions relying on reconnection, communication by dark photons, and attachment in invader molecule. Proteins began to serve as building bricks, as bio-catalysts, promote the replication of DNA, responding to stimuli, serve as receptors.

Possible mechanism of water memory and homeopathy

The general vision about prebiotic evolution described above suggests that the mechanisms of water memory and homeopathy are basically the same as those underlying the workings of the immune system.

- 1. Exclusion zones could define primordial life forms with genetic code. They are able to detect the presence of invader molecule from its cyclotron frequency spectrum.
- 2. Dark proteins can form concrete memory representations of the invader molecules in terms of dark proton sequences defining dark proteins. The folding of these dark proteins mimics the behavior of the magnetic bodies of the invaders. These dark proteins can attach to the magnetic body of the invader molecule to make it non-dangerous. Even symbolic representations in terms of dark DNA allowing transcription and translation to concrete dark protein representation could be involved. The procedure involved in the manufacture of homeopathic remedy could be seen as a series of "environmental catastrophes" driving the evolution of dark primordial life by feeding in metabolic energy and generating new EZs, which mimic the invader molecules and existing EZs mimicking them.
- 3. In organism the dark DNA representing the invader molecule would generate ordinary genes coding for ordinary proteins attaching to the invader molecules by the attachment of ordinary DNA nucleotides to them. The attachment would involve h_{eff} reducing phase transition reducing the length of connecting flux tube.
- 4. Later dark genetic code transformed to chemical genetic code as dark DNA strands were formed around dark double strands and large number of other biological functions emerged besides immune response.
- 5. The mechanical agitation in the manufacturing of homeopathic remedy generates exclusion zones and new primitive life forms by providing the needed energy. These in turn recognize and memorize invader molecules and their already existing representations as EZs.

8.9.3 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 [I68] (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) [I52, I7] have first suggested? Also TGD leads to a vision about living system as a conscious hologram [K24]. 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 [K62, 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 [L36], [K95]). 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 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 [K6].

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 are 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↔U and C↔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 [K62] 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 [K102] [L32] 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 and whether it relates to the icosatetrahedral realization of the code.

I have proposed [K69] (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 [J45] (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 its 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 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 (magnetic 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 [I52] 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 [J16] (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?

8.9.4 Is Replication Of Magnetic Body Behind Biological Replication?

The vision about exclusion zone (EZ) like regions as primordial life forms and facts about water memory and homeopathy lead to a vision about how primitive immune system might have developed and how the recent genetic code might have emerged.

Magnetic body and dark analogs of bio-polymers should still play key role in living matter. The basic idea is that the time evolution of the magnetic body is the template for the time evolution of the biological body. In [K99] [L34] various pieces of evidence for the role of magnetic body as "morphogenetic field" are discussed. For instance, the replication of DNA and cell would reduce basically to that for corresponding magnetic bodies.

Replication of magnetic body is analogous to what happens in 3-vertex of Feynman diagram. This occurs in several scales. This would make possible dark DNA (dDNA) replication and copying of dDNA to dDNA+dRNA as well as copying of dRNA to dRNA+dark protein.

Replication process should start from the higher levels of dark matter hierarchy and proceed to shorter scales. The basic constraint from ZEO is that the time evolutions of magnetic bodies at various levels of the hierarchy are highly unique as preferred extremals connecting initial and final 3-surfaces. For the maxima of vacuum functional only preferred pairs of 3-surfaces are possible. This gives rise to what might be called "standard behaviors". Also the replication would be this kind of behavioral pattern. In the context of the positive energy ontology it is extremely difficult to understand why the predictability of cell replication or the development of organism from single cell by repeated cell divisions.

Remote gene replication [K149] might be one application: the model described was actually developed before the idea that the replication of the magnetic body could be the fundamental mechanism. Its reversal could be basic mechanism of bio-catalysis and induce the attachment of bio-molecules together. Also ordinary DNA replication could be induced by the same electromagnetic signal as remote replication.

The sketch about replication of DNA would look roughly like following.

- 1. Assume that the portion of DNA promoting DNA replication is activated by dark radiation at some frequency and that the promoter region emits radiation with same frequency. This activates further promoter regions -also in other cell nuclei. The replication process is amplified exponentially. The negative feedback is necessary in the general case and is provided by attachment of the produced proteins (basically dark proteins) to the genes making them inactive.
- 2. This might occur during cell division which might involve irradiation by dark analog of white noise exciting all promoter regions. Certainly the coherence of this process is essential and here the higher levels of the dark matter hierarchy would be essential.
- 3. Remote replication becomes possible if the dark radiation exciting promoter region can leak to other cells or even other organisms. Large h_{eff} might make this possible.
- 4. Also remote transcription is possible by the same mechanism. Actually remote variants of very many basic processes seem to be possible.
- 5. The observations of Peter Gariaev's group about effects of laser light on genes [I54, I86] support this view as also the findings of group of HIV Nobelist Montagnier [I60, I61].

8.9.5 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 heff?

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 $h_{eff}/h = E_J/hf_{AC}$ [K12].

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 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 [K48, K101]. This would lead to a generalization of the notion of Josephson junction associated with the transmembrane protein and generalizes $f_J = f_{AC}$ to $\Delta f_c + f_J = f_A C$ 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 is 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} [K69] 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 [K122, K101]. Gravitational Planck constant can be expressed as $h_{qr} = GMm/v_0$, 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 [E2, E5]. 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 [?]. 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 [?]. 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 [L36], [K98] for Pollack's findings [L36] 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 μ 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, K62].
- 6. Negatively charged EZ could define a pre-biotic cell so that water would be a primitive prebiotic 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 ADP \rightarrow ATP process?

The identification of the exclusion zone with magnetic body as a basic structure allows to speculate about what might happen in $ADP \rightarrow ATP$ process and how ATP might store metabolic energy.

- 1. The strings of dark protons [K62] 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 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 magneti 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 [K15].

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 could B correspond some higher collective level of consciousness perhaps identifiable as gravitational Mother Gaia (MG) as suggested by the success of $h_{qr} = h_{eff}$ 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 $\hbar_{qr} = GMm/v_0$, 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 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/ybd4g2kl) 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 [K101] (see http://tinyurl.com/yat9bx9j).

- 1. NE is always between two systems: nutrient and something, call it X. The proposal inspired by a numerical co-incidence 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 supercounductor (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/yat9bx9).
- 2. Gravitational Planck constant $\hbar_{gr} = GMm/v_0$, v_0 typical velocity in system consisting of masses M >> 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 h_{gr} would 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 $h_{eff} = h_{gr}$ 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 h_{gr} hypothesis holds true only in microscopic scales. This would mean that gravitation in planetery 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. $h_{gr} = h_{eff}$ 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 [?]. 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 [K101]. 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.

8.9.6 Humble Origins Of DNA As Nutrient - Really Humble?

I received an interesting link (http://tinyurl.com/ybv8xu9uDNA_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 [I72]. Each nucleotide in the phosphatedeoxiribose 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 large 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, [K80]) 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 "Akaschic 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 co-incidences 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 [K95]. 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 astroscopic length scales.

8.10 More Precise View About Remote DNA Replication

Both Luc Montagnier [I60, I61] and Peter Gariaev [I78] have found strong evidence for what might be called remote replication of DNA. I have developed a TGD inspired model for remote replication using the data from Peter Gariaev [K149], who has developed the notion of wave DNA [I52] supported by Montagnier's findings.

Polymer chain reaction (PCR) [I22] provides a way to build copies of piece of DNA serving as template. Once single copy is produced, it serves as a template for a further copy so that exponential amplification is achieved. Montagnier's and Gariaev's works suggest however that the synthesis of DNA could also occur without a real matrix DNA as remote replication. According to the proposal of Gariaev [I52, I113] DNA template would be remotely represented as what he calls wave DNA. Montagnier [I61] uses 7 Hz ELF radiation to obtain the effect whereas Gariaev [I78] uses scattering of laser light into large interval of frequencies to achieve the effect.

In TGD approach magnetic body containing dark matter with large Planck constant, the associated cyclotron radiation for which energy scale is proportional to effective Planck constant $h_{eff} = n \times h$ having large values implying conjectured macroscopic quantum coherence of living matter, dark analog of DNA represented as dark proton sequences at magnetic flux tubes and accompanying ordinary DNA, plus reconnection of U-shaped magnetic flux tubes assignable to the magnetic bodies of biomolecules and allowing them to recognize each other, are the basic elements. The model has evolved from the attempts to understand water memory and homeopathy in TGD framework [K62].

Both 7 Hz ELF radiation and scattering of laser light would both generate dark photon (large Planck constant) spectrum with a wide spectrum of frequencies but with the same energy which in Gariaev's experiments would naturally be the energy of scatter laser light. The dark photons would provide representation for DNA codons. If 7 Hz frequency radiation involves dark photons with energies of visible photons transforming to ordinary photons before scattering from DNA the outcome would be same as in Gariaev's experiments.

This picture conforms with Gariaev's hologram idea and also with TGD based vision about living matter as a conscious hologram [K24]. The laser beam that Gariaev has used and the 7 Hz irradiation (involving dark ELF photons at bio-photon energies) would act as a reference beam allowing to read a biohologram coded by DNA and its magnetic body. The outcome is dark photons with same energy but with varying values of Planck constant and thus with varying frequencies propagating along magnetic flux tubes to the target, which could be exclusion zone (EZ). Flux tubes are characterised by h_{eff} and magnetic field strength B_{end} determining cyclotron frequency (coded by the transversal area by flux quantization if monopole flux is in question). Metabolic energy is needed to create EZ and could be provided either by the radiation itself or by the repeated heating. Negentropic entanglement is generated and creates the correlation between dark (phantom) DNA codons and ordinary DNA codons.

The following involves same elements as the model discussed in [K149] but there are also new elements due to the developments in the model of dark DNA allowing to imagine a detailed mechanism for how water can represent DNA and how DNA could be transcribed to dark DNA. The transcription/association represents a rule and rules are represented in terms of negentropic entanglement in TGD framework with pairs of states in superposition representing the instances of the rule. Transition energy serves as a characterizer of a molecule - say DNA codon - and the entangled state is a superposition of pairs in which either molecule is excited or dark DNA codon is excited to higher cyclotron state with same energy: this requires tuning of the magnetic field and sufficiently large value of h_{eff} at the flux tube. Negentropic entanglement is due to the exchange of dark photons: this corresponds to wave DNA aspect. Dark cyclotron photons also generate negatively charged exclusion zones (EZs) discovered by Pollack and in this process transform part of protons to dark ones residing at the magnetic flux tubes associated with EZs and forming dark proton sequencies.

8.10.1 Some Background

The model for remote replication involves the following basic building bricks.

- 1. Dark variant of DNA realized as dark proton strings representing dark nuclei.
- 2. The identification of bio-photons as decay products of dark cyclotron photons with large value of h_{eff} having universal energy spectrum due to the condition $h_{eff} = h_{qr}$.
- 3. TGD explanation for the fourth phase of water discovered by Pollack [L36] and characterized by negatively charged exclusion zones EZs generated by radiation.
- 4. A model for the radiative coding of DNA creating 1-1 correlation between ordinary and dark DNA codons and between two dark DNA codons.

Dark DNA as dark proton strings

TGD leads to a model of nuclei as nucleons strings [L3]. The model generalizes to the dark matter sector [L3, K62].

1. I have proposed the notion of dark DNA realized as dark proton sequences (3 quark states), which I have argued ton basis of a simple model to form representations for DNA, RNA,

amino-acids and even tRNA is central for TGD inspired biology. Biochemistry would define only a secondary representation for more fundamental realization of genetic code and analogs of basic biomolecules in terms of dark nuclear physics.

I have conjectured that translations, transcription, etc generalize and apply to pairs of ordinary and dark and dark and dark DNA and amino-acids. One could even consider that dark DNA would make possible induction of genetic changes: transfer dark DNA inside germ cells and transform them to ordinary DNA and attach to existing DNA. If dark DNA can be generated by radiation as wave DNA notion suggests then radiation from other cells to germ cells could induced genetic changes. Living systems would have kind of Research and Discovery apartment developing new candidates for genes. Evolution would be the opposite for blind random trials.

2. I have also proposed that immune system could have developed from what is basic mechanism of homeopathy and water memory. The magnetic bodies of water clusters mimic invader molecules - or rather their magnetic bodies. What is needed is a representation for cyclotron frequencies so that radiation would emerge in this phase. Cyclotron frequency spectrum would represent the invader and the simplest mimicry of invader molecule would be water structure with magnetic body characterized by same cyclotron frequency spectrum: water memory in short. Also the braiding of the magnetic body of the invader might be mimicked. Protein folding might be a chemical representation for this braiding and the proteins of immune system might mimic the braidings of the magnetic bodies of the invader molecules. DNA in turn would give a symbolic representation of proteins allowing to construct them when needed. Ordinary DNA and proteins would have been preceded by dark DNA and dark proteins. I have even proposed an interpretation of genetic code based on the idea that it represents the dynamical evolution of braiding of the magnetic body - or 2-braiding [K99].

The basic mechanism of directed attention or sensing the presence of the invader molecule would be reconnection of U shape flux tubes of the magnetic bodies of the two system. Also resonant interaction by cyclotron radiation inducing cyclotron transitions is expected to be an essential piece of the mechanism. Magnetic body of water cluster could tune the thickness of flux tube so that the magnetic field is same as that in the flux tube of invader molecule so that primitive consciousness and act of free will would be involved.

3. Suppose that DNA codes for proteins, their cyclotron frequency spectrum and their braiding and knotting in protein folding in turn representing invader molecule. Is the frequency spectrum all that is needed to represent DNA and construct its dark variant? The experiments of Benveniste and followers [I48, I49] suggest that invader molecules are indeed represented by the cyclotron frequency spectrum alone. This would suggest connection with wave DNA concept.

Universality of cyclotron energy spectrum and bio-photons as decay products of dark photons

There are good empirical motivations [K95] to expect that the cyclotron energy spectrum is universal and in the range of bio-photon energy spectrum. This is achieved if h_{eff} is proportional to the mass m of the charged particle so that cyclotron energy $\hbar_{eff}eB/m$ is independent of mass and same for all charged particles.

Universality follows also from the condition that gravitational and biological Planck constants are identical: $h_{gr} = h_{eff}$, where $\hbar_{gr} = GMm/v_0$ is the gravitational Planck constant introduced by Nottale and assigned with the flux tubes mediating gravitational interaction in TGD Universe. The condition states that electromagnetic and gravitational flux tubes have same the value of effective Planck constant meaning that also gravitation would become a key player in biology.

Fourth phase of water, EZs, and metabolic role of cyclotron radiation

The experiments of Pollack [L36] suggest a partial answer to the question. in terms of what he calls fourth phase of water containing negatively charged regions, exclusion zones (EZ) of size up to 200 micrometers.

1. Irradiation of water by visible light generates negatively charged regions which he calls exclusion zones (EZs). The energy goes to the formation of electric voltage between exterior and interior and is analogous to cell membrane potential. Predecessor of cell could be in question. Some fraction of protons must go outside the system and my proposal is that it goes to magnetic flux tubes and forms dark proton sequences defining the analogs of basic bio-molecules. The $H_{1.5}O$ stoichiometry of EZs [L36] characterizing also earlier findings suggesting that one fourth of protons of water are dark in attosecond time scale (not visible in electron scattering and neutron diffraction) suggests that every fourth proton disappears from EZ. This anomaly was one of the strong motivations for taking the idea about dark matter as large h_{eff} phases seriously [K55].

These structures would be involved also with water memory and homeopathy and immune system would have emerged from these. Free energy researchers know these regions quite well [H8] (no-one of course takes them seriously!) and they can be generated by just feeding energy to system used as metabolic energy. In homeopathy the mechanical agitation would do this and induce replication and perhaps even evolution of the resulting primitive lifeforms. Cavitation, use of strong electric field, maybe even heating used in PRC, etc... are possible mechanisms of energy feed.

- 2. The cyclotron radiation at cyclotron frequencies associated with flux tubes emanating from DNA codons could provide the energy needed to induce the formation of EZs. This would be the first function for the radiation.
- 3. If the DNA end of flux tube contains dark proton in state which corresponds to the DNA in one-one manner then the mass of the dark proton state would assign to it a unique cyclotron frequency distinguishing between DNA codons. The challenge is to understand the mechanism of DNA dark DNA pairing and dark DNA-dark DNA pairing and one expects resonant binding by exchange of dark cyclotron photons.

Pairing ordinary and dark DNA codons and two identical dark DNA codons by negentropic entanglement

One should understand the pairing of ordinary and dark DNA. As a matter fact, this pairing defines a realization of the genetic code as a physical 1-1 correlation of DNA codons with some physical states. I have consider this kind of realizations also in the model of DNA as topological quantum computer. The following realization relies on resonant interaction by exchange of dark cyclotron photons and can be seen as radiation based.

- 1. The most natural association between ordinary and dark DNA would via energy resonance. The energy for some molecular transition of DNA (in bio-photon energy range by argument below) would be same as cyclotron energy for the codon with large value of $h_{eff} = n \times h$ making cyclotron energy large.
- 2. By suitably tuning the value of the magnetic field *B* associated with the flux tube accompanying ordinary DNA codon the dark cyclotron energy can be tuned to be equal to the value of some biochemical transition energy of DNA, which is in visible and UV range typically that is in the energy range of bio-photons.
- 3. Classically DNA codon and its dark variant can be thought of as exchanging forth and back dark photon at resonance frequency and become strongly correlated in this manner like tennis players during game. Quantum mechanically one has quantum entangled Schrödinger cat like state in which state pairs have same total energy but individual states do not have well-defined energy.
- 4. The correlation between dark proton states at two ends of flux tube would be realized as formation of bound state via resonant exchange of dark cyclotron photons. Negentropically entangled [K80] superposition for which simplest the possible form is $|n\rangle|n+1\rangle + |n+1\rangle|n\rangle$ of paired cyclotron states would be generated. DNA and dark DNA codons would pair to a negentropically entangled state in similar manner. Recall that in TGD framework negentropic entanglement (NE) carries potentially conscious information: the state represents a rule whose instances correspond to the state pairs in the superposition [K80].

5. One can consider also 3-particle NE of DNA codon and 2 dark DNA codons which is superposition of three 3-particle states with one particle excited to higher energy state with the same energy. DNA codon would be excited chemically and dark codons excited to cyclotron state $(n \rightarrow n+1)$. 3-dimensional permutation symbol defines this kind of state. Also NE for larger number of particles is possible.

The tuning of the flux tube magnetic field to make cyclotron energy equal to chemical transition energy is possible for arbitrary biochemical transition energies and the association of dark proton states to arbitrary biomolecules is in principle possible via same mechanism. This would be essentially a symbolic representation of biomolecule, a name for molecule. If one has some number of different molecules able to form sequences, these sequences can be remotely reconstructed by using the cyclotron frequencies and transversal flux tubes associated with the template to generate the EZs and the name of the polymer to which the building bricks bind resonantly.

If the condition $h_{eff} = h_{gr}$ holds true, one can use instead of dark proton sequences sequences of *any* dark charged particles - say electrons and ions. Hence almost an unlimited repertoire of representations arises. These correspondences need not to be one-one. For instance, DNA-aminoacid 64-to-20 correspondence is possible to realize with the help of dark variants of DNA codons and amino-acids and also the partially or totally dark variants of this correspondence are possible.

This pairing mechanism would allow resonant interactions of the ordinary DNA codons in water and dark DNA codons induced by the dark cyclotron radiation and could play key role also in ordinary DNA replication and also in the remote replication reported by Montagnier [I61] and Gariaev [K149]. A phase transition reducing h_{eff} would bring ordinary and dark codon together and ordinary biochemistry would take care of the rest. Clearly, this mechanism would also allow biomolecules connected by magnetic flux tubes to find each other in molecular soup with pairing following by a phase transition reducing h_{eff} .

8.10.2 Does Remote Replication Apply Same Mechanism As MimicryOf Invader Molecules In The Case Of Water Memory?

Somehow the irradiation of water sample with the cyclotron radiation generated by real DNA should induce or be involved with the generation of dark DNA representing the ordinary DNA and the PCR process would use this dark DNA as template an involves pairing of ordinary and dark DNA nucleotides. How this could happen in TGD Universe?

The mechanism of remote DNA replication without chemical template would be essentially the same as in the TGD based model of water memory [K62] underlying also the model of homeopathy circumventing the ultra-naïve skeptic argument that homeopathy is not possible because the density of molecules dissolved in water is practically zero.

The cyclotron frequency spectrum allows to create EZ whose magnetic body mimics the invader molecule. Resonant formation of negentropically entangled pairs would define a realization of genetic code based on radiation and dark cyclotron radiation would give rise to the formation of EZs and accompanying dark proton sequences.

In the recent case invader molecule would be replaced with DNA expressing its presence using dark cyclotron radiation propagating along the flux tubes transversal to codons and forming part of the magnetic body of DNA. The magnetic flux tube of ordinary DNA codon realizing dark proton sequence as dark variant of DNA codon would generate its own representation by generating EZs in water.

The rules would be following.

1. Magnetic fields at U-shaped flux tubes associated with codons and dark codons must be equal so that also cyclotron frequencies coding for dark proton masses and therefore for dark proton states would be equal so that frequency and energy resonance is possible and negentropically entangled state is formed. This assigns by resonance mechanism to the second end of flux tube same dark proton state as to the end near ordinary DNA. Recall that U-shape is essential for bio-super-conductivity based on large value of h_{eff} making possible large and negative spin-spin interaction energy for electrons of pair located at parallel flux tubes [K26, K100].

As described, binding is generated by resonant exchange of dark cyclotron photons between the ends which are in superposition of different cyclotron states. Magnetic field value in turn corresponds directly to ordinary DNA codon - or rather its transition in bio-photon energy range. It is essential that the value of magnetic field codes for ordinary DNA codon via a biochemical transition energy associated with it. One can imagine that magnetic body can tune the value of field by changing the transversal area of the flux tube carrying monopole flux (possible in TGD due to the CP_2 topology). Similar tuning would be involved when the magnetic bodies assignable to EZs detect possible invader molecules. Interestingly, the impurity molecules inside EZs are removed by unknown mechanism citebbioPollackYoutube.

2. Dark DNA codons associated with DNA would have U-shaped flux tubes which for large h_{eff} would extend to the water sample containing building bricks of DNA and catalyst. The flux tubes associated with dark DNA and building bricks of ordinary DNA would reconnect resonantly and lead to remote replication of DNA strand.

This option is definitely not the only possibility one can imagine but represents the general principle. For instance, one can consider using only DNA-dark DNA complex and inducing h_{eff} increasing phase transition transferring the dark DNA strand to the volume of the water sample. The mechanism allows also to consider remote translation of genes to proteins. The possible medical applications of this in a situation in which the DNA of the patient has suffered a mutation causing a disease are obvious.

8.11 Remote replication again

In TGD inspired vision about quantum biology relying on the notion of magnetic body (MB) carrying dark matter as phases of ordinary matter with effective Planck constant $h_{eff} = n \times h_0$ one ends up with the notion of dark DNA realized as sequences of dark protons and to the surprising finding that dark proton triplets realize vertebrate genetic code and basic biomolecules DNA,RNA,tRNA, and amino-acids [L44, L80].

The objection against dark photon 3-chords (3-photon states) is that the simultaneous emission of 3 dark photons used in communications as 6-bit unit is extremely non-probable. A possible solution of the problem is that dark photons carry number theoretic color associated with Z_3 subgroup of Galois group. Number theoretic color confinement would imply that only 3-chords can appear as asymptotic states analogous to baryons. If dark protons are also number theoretic color triplet, dark codons must consists of 3 protons and therefore also ordinary codons have 3 letters.

The findings of Montagnier *et al* [I61] (http://arxiv.org/abs/1012.5166) raise the possibility of remote replication of DNA. Montangier's experiment involves two chambers A and B. A contained water and genes and B water and DNA nucleotides. There were channels between the chambers but so thin that DNA could not get through. Besides this there was present em field with 7 Hz frequency. Same genes as in A appeared also in B. As if remote replication of genes in A had happened in B. I have written an articles about Montagnier's findings [L20, L33]. Gariaev has reported similar phenomenon already before Montagnier *et al*: we wrote together an article discussing TGD based model for the finding [K149].

How did the genetic information pass to B and how the remote replication took place? Somehow the radiation made the remote replication possible or at least more probable. Clearly the information about gene - not only about codons but also about their order and relative positions - should have been communicated from A to B. I have already earlier considered this problem but found no satisfactory solution to it.

Concerning the role of the 7 Hz frequency, there are two hints.

1. The nominal value of the lowest Schumann frequency is 7.8 Hz, not far from 7 Hz. Could one think that macroscopic quantum coherence in the scale of Earth was involved. 7.8 Hz correspond to wavelength equal to circumference of Earth.

"Endogenous" magnetic field $B_e nd = .2$ Gauss identifiable as the monopole flux part of the Earth's magnetic field $B_E = .5$ Gauss explains the findings of Blackman [J23] and others about quantal looking effects of radiation at frequencies seem to be multiples of cyclotron frequencies of biologically important ions.

The problem is that the energies of cyclotron photons are ridiculously small for ordinary value of Planck constant. This was one of the motivations for the hypothesis that dark matter corresponds to phases of ordinary matter with effective Planck constant $h_{eff} = n \times h_0$ [K99, K100, K101]. The cyclotron frequency of K ion is $f_c(K^+) = 7.1$ Hz. The flux tubes with length of corresponding cyclotron frequency are also of the order of Earth circumference.

This raises several questions.

- 1. Did water generate flux tubes with magnetic field with frequency equal to $f_c(K^+) = 7.1$ Hz and strengthening coupling to a radiation with Schumann frequency or K cyclotron frequency or both so that the communications with the MB of Earth or/and layer of MB corresponding to K cyclotron was strengthened? The TGD based mechanism of water memory [K62] would be involved.
- 2. Did this make the remote replication more probable? How?
- 3. What DNA actually looks like in TGD Universe? What actually happens in DNA replication? What could happen in remote DNA replication?

In the sequel the questions whether cyclotron frequency or Schumann frequency or both were involved and how their presence made possible remote replication remain without detailed answer although it is clear that the presence of dark photons with this frequency should make possible the control by MB generating coherence of ordinary matter in the scale determined by the sizes of the chambers. These questions however led to a considerable increase in the understanding of dark variants of genetic code predicted by TGD [L44, L32, L97].

- 1. To understand remote replication one must understand replication. Dark codons do not decompose into letters like chemical codons: this poses strong constraints on the replication and transcription if one assumes DDNA-DNA-pairing. These constraints strongly suggests that the nucleotides in the water environment of DNA are not actually free but form loosely bound triplets representing codons and bound with DDNAs. This means a new variant of genetic code realizing codons as loose triplets of nucleotides in the water environment.
- 2. This proposal brings in mind TGD based model for viruses, which can decompose into pieces shared between several host cells and re-combine later as also the observation that the dense states of bacteria population have resemblance to multi-cellular embryos. The common TGD inspired explanation [L105] would be that the pieces of virus and cells of bacterial population are connected by magnetic flux tubes and form a single loosely bound unit at the level of MB. The prediction is that replication occurs in codon-wise manner: this has been observed to be possible for RNA [L85]. It might be that the loose nature of exotic DNA codons allows this to occur quite generally.
- 3. Remote replication in this framework reduces to ordinary replication in TGD sense if also dark genes are formed by attaching flux tubes characterizing dark codons to a long flux tube associated with gene. Remote replication requires that the portion of dark gene accompanying ordinary gene is transferred from chamber A to chamber B in the experiment of Montagnier.

8.11.1 Three variants of genetic code

The notions of MB and view about dark matter leads to 3 variants of genetic code.

1. The notion of MB suggests that dark proton sequences assumed to explain Pollack effect (http://tinyurl.com/gwasd8o) [L36] realize dark genetic code. Dark DNA (DDNA) codon would correspond to 3-proton triplet assignable to closed flux tubes attached to a a long flux tube by U-shaped flux tube appendix giving rise to dark gene (http://tinyurl.com/jgfjlbe). Attaching means formation of U-shaped appendices from long flux tube and DDNA codon which reconnect to a pair of flux tubes. 3-proton states define dark analogs of DNA, RNA, tRNA, and amino-acids (DDNA, DRNA, DtRNA, DAA) [L44, L80]. The numbers of DDNAs coding for given DAA are same as for vertebrate genetic code.

2. Second dark code is needed for communications and realizes genetic codons as dark 3-photon states - 3-chords of bio-harmony [L32, L92, L97] (http://tinyurl.com/yad4tqwl). The model emerged from a model of musical harmony based on icosahedron and tetrahedron. 12-note scale is identified as a Hamiltonian cycle - a path going through all 12 vertices of icosahedron - such that going from vertex to neighbor corresponds to quint. Hamiltonian cycles have cyclic group Z_n , where n = 0, 2, 4, 6 is the order of the group, as symmetries. n = 0 corresponds to chaotic orbit and disharmony. Each of the 20 faces - triangles - corresponds to a chord of given harmony.

One identifies the orbit of given face as DAA coded by faces (DDNAs) at the orbit. By combining 3 harmonies with n = 6, n = 4 and n = 2 one obtains 20+20+20 chords and the numbers of DNA coding given AA are essentially those in vertebrate code. By gluing tetrahedron to one face one obtains 4 additional chords (DDNAs) and 1 additional note very near to one of the notes of Pythagorean scale, whose problem is that it does not quite close. The numbers for analogs of DNA codons coding for for given DAA are same as for vertebrate code.

The chords would be represented as "music of light" as states of 3 dark photons. Music expresses and creates emotions and bio-harmony would provide a physical correlate for emotional states at molecular level [L86].

3. Dark codes would be fundamental and chemical code would be their mimicry. One expects DDNA-DNA pairing with DDNA codons represented as dark proton triplets. DDNA codons and dark photon chords have no decomposition to letters (chinese and western languages provide an analog). This suggests that DNA replication and transcription cannot take letterwise but but codon-wise. Amazingly, there is evidence that DNA replicates in codon-wise manner during RNA era: I have commented this in [L85].

Nucleotides/letters in the water environment of DNA double strand should appear as loosely bound but correlated triplets of nucleotides associated with closed flux tubes containing dark DNA codon. They would represent exotic DNA codons. This would force fixed order of nucleotides essential for the code. By absence of valence bonds between nucleotides they would be effectively free but strongly correlated. This representation of the code would be crucial for replication and transcription.

These 3 codes allow to understand replication and transcription of DNA replaced in TGD with DDNA-DNA pair. The prediction is that the replication takes place codon by codon and might kill the model.

A model of replication based on this picture generalizes to remote replication suggested by the findings of Montagnier [I61]. The DDNA codons of ordinary DNA strand would be attached with a long side of closed flux tube as dark gene. In remote replication h_{eff} of dark gene would change and dark gene would be transferred to chamber B from A. After that the replication would proceed as usual.

8.11.2 An objection against bio-harmony

There is a serious objection against the realization of dark genetic code in terms of bio-harmony. The emission of 3 dark photons simultaneously looks extremely non-probable process.

Number theoretical physics suggests a solution of the problem. Number theoretical physics [L73] (http://tinyurl.com/zylrd7w) is a central part of quantum TGD and quantum biology and provides physical correlates for cognition. It explains dark matter as $h_{eff} = nh_0$ phases of ordinary matter with n identified as order of Galois group of extension of rationals and as dimension of extension. This picture predicts automatically evolution as increase of n in quantum jumps.

1. There is analogy with color confinement. Baryons consist of 3 quarks. Color symmetry is a symmetry of strong interactions and quarks form color triplets. Free quarks do not appear in the final states, which give rise to color confinement: only color singlets, in particular baryons consisting of 3 quarks and mesons consisting of quark and antiquark are possible.

This suggests that also now there must be a symmetry such that dark photons have new quantum numbers, which vanish for physical states such as dark photon triplets.
2. What these quantum numbers could be? The only candidate, which comes in mind are discrete quantum numbers related to the Galois group of extension of rationals defining number theoretic symmetry. For ordinary $h = 6h_0$ Galois group has n = 6 elements and equals to $Z_6 = Z_2 \times Z_3$.

It appears as subgroup of higher Galois groups for which $h_{eff} = n \times h = 6nh_0$ one would have extension of extension. Z_3 confinement would require 3-photon states, which are Z_3 singlets with number theoretic colors summing up to zero. One would obtain only 3-chords. Ordinary photons would be Z_3 singlets.

3. Also the 3 protons of DDNA codon could form Z_3 triplet. Number theoretic color confinement would allow only 3-proton triplets. Genetic code is predicted correctly and the number letters in the codons is predicted to be 3.

This raises two interesting questions.

- 1. Quantum-classical correspondence (QCC) is a exact part of TGD. Therefore I have considered the possibility that all physical symmetries could have number theoretical space-time correlates. However, at space-time level one cannot have representations of color group with non-vanishing triality $t = 0, \pm 1$. Same applies to spin half-odd integer representations of rotation group. Could $SU(2) \times SU(3)$ representations with triality $t = \pm 1$ and spin half-odd integer have triplet representation of Z_3 and double representation of Z_2 as space-time correlates? Z_6 would be the minimal Galois group allowing to realize spin and color for quarks.
- 2. Number theoretical physics predicts that Galois group for any extension of rationals acts as new hidden discrete symmetry. Could number theoretical confinement implying new selection rules be true quite generally? The larger the degree n of extension (h_eff) , the larger the scale in which confinement holds true, is. For instance, genes could be analogs of color singlet many particle states for a larger subgroup.

This is not the only option. I have already earlier considered with Peter Gariaev [K149] a proposal in which dark photons would communicate the genetic information from A to B. The problem is how the massless extremals (MEs) [K14] associated with them can be parallel and of same length: this would require that they form a quantum coherent entity. Could one consider a modification of the above proposal assuming that gene is an entity of N codons confined number theoretically? Could one can speak about dark photon genes as composites of N dark photon 3-chords? The information would be sent by dark photon gene representing entire music piece, as one might say. In chamber B energy-frequency resonance would generate a linear configuration of exotic codons, which would reduce to DDNA-DNA pair when h_{eff} is reduced.

8.11.3 DDNA-DNA, DDNA-DDNA, DDNA-exotic DNA pairings

The idea about MB as boss of BB suggests that DNA is accompanied by DDNA. DDNA would be the fundamental DNA and ordinary DNA emerged later as a kind of mimicry and there would be DDNA-DNA pairing.

The basic problem problem is that DDNA codons do not allow decomposition into letters like DNA codons. It seems that replication and transcription must occur codon by codon rather than letter by letter. For translation of mRNA this is indeed the case: tRNA are the basic objects. Could this be true in modified sense also for replication and transcription? In fact, RNA can replicate in codon-wise manner [L85]. Could this occur quite generally, and could the codons for replication believed to occur letter-wise be present in a latent manner?

DNA and DDNA codons

At least 3 new kind of codons are predicted (http://tinyurl.com/yygqen5g).

1. Also ordinary DNA codons involve flux tubes. Valence bonds between nucleotides of DNA strand and hydrogen bonds in double strand involve flux tubes or pairs of them.

2. DDNA codons are paired with ordinary DNA codons of DNA strand. DDNA codons would correspond to dark proton triplets at flux loops being analogous to tritium and ³He. The model for remote replication requires that DDNA codon loops are connected to long closed dark gene flux loop by U-shaped appendages - attached to dark gene.

If DDNA and DNA codons are paired with ordinary DNA by energy resonance there is no need for flux tube contacts between the triplets.

- 3. Dark codons as dark photon 3-chords are predicted. Couple to DDNA by energy-frequency resonance and to DNA by energy-resonance.
- 4. Exotic DNA codons are required by the model of replication. DNA nucleotides in environment would combine to exotic codons paired with DDNA codons.

What various pairings do look like?

There would be 3 kinds of pairings. This would predict that nucleotides appear as apparently free entities in the water environment.

- 1. DDNA-DNA pairing in DNA strand. Different values of h_{eff} do not allow flux tubes contacts. Energy resonance only.
- 2. DDNA-DDNA pairing in DNA double strand is not necessary in geometric sense as flux tube connections because hydrogen bonds pair DNA codons and energy resonance pairs DDNA strands to DNA codons. DDNA codons could be however located along dark gene flux tube and attached to it by flux tube pairs.
- 3. DDNA-exotic DNA pairing would take place in environment. Nucleotides of exotic DNA would be attached to closed DDNA codon flux tubes. h_{eff} would be larger than for DDNA codon in double strand. There would be no valence bonds between nucleotides. The ordering of letters would be forced by flux tube containing the dark codon and energy resonance. One obtains correct codon if the orientation of the flux tube matters (ABC and BCA correspond to different energies in energy resonance). Strong parity breaking allowed by TGD and realized in living matter would imply it.

This would solve the basic problem. Codon would be secretly present since there would be no valence bonds, which together with small string tension would mean that nucleotides are effectively free.

4. It is of course not clear whether this is enough to explain experimental findings. If one can demonstrate experimentally that the build-up of DNA strand in replication really occurs in letter-wise manner, the proposed model must be modified (not of course clear whether this is possible). The codon-wise coding, which can occur for RNA [L85] could be understood if the value of h_{eff} for DRNA strand can be same or nearly the same as in RNA strand.

8.12 TGD Inspired Model For The Formation Of Exclusion Zones From Coherence Regions

There is a talk of Mae-Wan Ho (http://tinyurl.com/ybbyn4pc) in Conference on the Physics, Chemistry and Biology of Water 2014. It is a very nice representation and I learned new facts highly relevant for my own work.

Some background articles might be helpful. Mae-Wan Ho [I93] has proposed that there exists superconducting liquid crystal water aligned with collage fibres. Giudice *et al* [I47] have proposed that water dynamics is at the root of metamorphosis in living matter: this involves the notion of water coherent region (CD) with size scale of 1 micrometer. I have not considered this notion in TGD framework earlier but TGD strongly suggests that the four Gaussian Mersennes $M_{G,k}$, k =151, 157, 164, 167 with corresponding p-adic length scales coming as $L(k) = 2^{(k-151)/2} times L(151)$, L(151)=10 nm are important in biology: k = 167 corresponds to 2.5 micrometers. Pollack and *et al* [I137, I115] have introduced the concept of exclusion zone (EZ) with size scale of 200 nm and related notion fourth phase of water. TGD inspired model of EZ involves in essential manner dark protons at magnetic flux tubes assignable to EZ [K95, K99].

The main points of Mae-Wan Ho's talk are following.

- 1. Protons make water a conductor, maybe even superconductor. In TGD framework the statement would be that dark protons flowing along magnetic flux tubes make this possible. Personally I believe that electronic and even ionic Cooper pairs are are involved and TGD based model of cell membrane [K120] assumes these super-conductivities relying on the notion of dark matter realizes as $h_{eff} = n \times h$ phases.
- 2. The water associated with collagen networks appears as superconductor and superfluid in nano-scales. Also this is very attractive idea and if the $h_{eff} = h_{gr}$ condition holds as some arguments suggest, then superfluidity allowing macroscopic quantum coherence with gravitational Compton length having no dependence on the mass of particle becomes possible [K95]. This is due to two facts. First, one has $\hbar_{gr} = GMm/v_0$, where M can be identified as dark part of the Earth's mass, m is the mass of the particle and v_0 is velocity parameter. Secondly, Compton length is inversely proportional to the mass. One of the strange effects involved with superfluidity is fountain effect explained elegantly by macroscopic quantum gravitational coherence: water would effectively defy gravitation: this effect might allow testing of the hypothesis.

8.12.1 CDs And EZs

Mae Wan-Ho talked about and compared two notions: CDs (coherent domains of water with size of about micrometer postulated by quantum field theoreticians, in particular Emilio del Giudice) and EZs (exclusion domains with size about 200 micrometers discovered by Gerald Pollack and collaborators experimentally). Note that in Zero Energy Ontology (ZEO) I talk about causal diamonds (CDs), which are typically much larger than CDs of Giudice *et al.*

- 1. Inside EZ the water forms layered structure consisting of hexagonal layers and the stoichiometry is $H_{1.5}O$ so that every fourth proton must be outside EZ (proton is not accompanied by electron if charge separation takes place: EZ is indeed negatively charged so that one obtains different pHs inside EZ and in its exterior). This state is experimentally heavier than ordinary water.
- 2. So called tetrahedral or 4-coordinated water is assigned with CDs. CDs and EZs could correspond to two different p-adic length scales in TGD framework. This state would be less dense than ordinary water. Both CD and EZ contain plasma of almost free electrons. CDs are excited to 12.06 eV just.5 eV below the ionizing potential 12.56 eV..5 eV which is the nominal value of metabolic energy quantum probably not an accident.

8.12.2 TGD Inspired Model For CDs And EZs

I try my best to summarise some very interesting points of the talk and develop in more detail TGD inspired model for EZs and their formation, and the TGD view of metabolism leading to a prediction of new form of metabolism involving dark UV photons from Sun.

- 1. The splitting of ordinary water H_2O to $2H^++2e^- + O$ is a key step in photosynthesis. In particular, it produces oxygen without which which we cannot survive. The splitting process involves two ionizations. The ionisation energy of the first electron 12.56 eV and in ultraviolet much above the metabolic energy quantum around 5 eV. How the splitting of water can be achieved at all? This looks like a very real problem!
- 2. CDs/EZs could be the solution to the problem. Inside CD the energy for the splitting of water is much smaller due to the fact that electrons are almost free as already mentioned: if the splitting energy equals to the so called formation energy, it is about.41 eV for CD: nothing but the metabolic energy quantum! Also at the interace of EZ just above the boundary of EZ the electronic states are excited and only an energy of .51 eV known as formation energy is needed for the splitting. This suggests that metabolic energy quanta are used to generate

EZs and/or CDs in the fundamental step metabolism. Also irradiation at these energies generates CDs/EZs.

3. My layman logic says that formation energy for EZ must correspond to the energy needed to increase the size of /EZ by a minimum amount. In TGD model this would mean creating one proton-electron pair such that electron remains inside the EZ, whose size thus increases and proton becomes dark proton at dark magnetic flux tube. This step would be also a key step in the splitting of water. Splitting of water and growth of EZ would be essentially the same process. In the case of CD it would seem that charge separation takes place inside CD in the splitting and proton can go outside.

What comes in mind that the formation of CDs requiring large excitation UV energy of 12.06 eV precedes that of EZs. After the formation of CD and almost free electrons only metabolic energy quantum per proton is required to kick single proton to dark magnetic flux tube. This would conform with the fact that CD radius is about 200 times larger than that of CD meaning that volumes are related by a factor $8 \times 10^6 \simeq 2^{23}$. The formation of EZ would transform tetrahedral water to the hexagonal $H_{1.5}O$ and suck protons to dark protons at magnetic flux tubes. If this picture is correct, the proper identification of formation energy for CD would be as absorption energy for CD equal to 12.06 eV and in UV. Recall that bio-photon spectrum extends to UV and dark photons with this energy could be responsible for the formation of CDs. This would adde dark photons transforming to bio-photons to the picture.

The formation of EZ can be seen as pulling out one ordinary proton from ordinary water just above the surface of the EZ and making it dark proton at a magnetic flux tube assignable to the EZ and perhaps connecting it to neighboring EZ for form a quantum coherent network. Dark proton would serve as a current carrier and make water a conductor and perhaps even super-conductor. Even superfluidity can be considered.

4. The metabolic energy quantum.5 eV can be also assigned with hydrogen bond. Could the process of generating dark proton and increasing the size of EZ by one electron involve cutting of the hydrogen bond binding the proton to the water outside. If so then the only thing keeping the excited water inside CD as a coherent phase would be the bond energy of hydrogen bonds! Maybe this is too simplistic.

I have proposed earlier that hydrogen bonds are short magnetic flux flux tubes, which can suffer h_{eff} increasing phase transition. These flux tubes could in turn experience reconnections with U shaped large h_{eff} flux tubes and get connected to the dark web. Mae-Wan Ho also tells that the transfer of proton from covalent OH bond to the middle of hydrogen bond happens with a considerable probability. Could this step precede the increase of h_{eff} and reconnection? This would give a connection with hydrogen bonding about which Mae Wan-Ho also talked about. These naïve models of course cannot be correct in detail but give hopes about fusion of existing chemical thinking and new quantal notions.

5. A process bringing in mind the formation of EZs occurs as one perturbs molecular biosystems - that is feeds energy into it. The system "wakes up" from "winter sleep", the globular proteins, which are in resting state with hydrogen bonds at their surface forming kind of ice layer unfold and protein aggregates are formed. Molecular summer begins and ceases when the energy feed is over. Cellular winter begins again. Maybe cellular summer is just temporary formation of EZ layers around the protein involving melting of hydrogen bonds and generation of dark protons making system conscious!

8.12.3 Is A New Source Of Metabolic Energy Needed?

What remains to be understood is the process generating CDs: where could the UV photons with energy 12.06 eV come? Clearly a new form of metabolism is involved and the only source of energy seems to be the Sun!

1. Solar radiation cannot however provide UV photons as ordinary photons since UV radiation at these wavelengths is absorbed by the atmosphere. In TGD framework a reasonable candidate for dark radiation with energies in UV range is dark cyclotron radiation with energy $E = h_{eff} \times f$: biophotons would be produced in the transformation of dark cyclotron photons to ordinary photons.

2. Could part of solar UV radiation transform to dark UV photons at magnetic flux tubes of even size scales larger than that of Earth predicted by the model of EEG and arrive along them through the atmosphere? The presence of a new source of metabolic energy is in principle a testable prediction: is the energy feed from the visible part of solar radiation really enough to cover the metabolic energy needs? Here one must however take into account the fact that the UV energy would be received by water. The water from which CDs are eliminated would not allow photosynthesis.

To sum up, if the proposed picture is correct photosynthesis involves formation of EZs and cellular respiration the inverse of this process. As discussed earlier, the purpose of metabolic processes would be basically generation and transfer of negentropic entanglement assignable to large h_{eff} states.

8.13 Connections To The Work Of Other Researchers In The Forefront

Many connections with the workers in the field have emerged. In the following I list some articles in chronological order. Some of the people included have not worked with remote mental interactions but in TGD world order their work relates rather closely to this field so that I have included them.

8.13.1 Mae Wan-Ho

Mae Wan-Ho is one of the pioneers of the new biology. She emphasizes the fact that genetic code is not enough to understand inheritance (see article *Mystery of Missing Heritability Solved* (see http://tinyurl.com/y7f4b5rz [I108]), that genes alone do not determine body patterns (see article it Genes don't Generate Body Patterns (see http://tinyurl.com/y9tyslwv) [I107]), that there are no genes for intelligence (see article *No Genes for Intelligence in the Human Genome* (see http://tinyurl.com/ycxdoz3h) [I109]). In TGD framework the notion of magnetic body could provide the umbrella concept suggesting braiding as a universal mechanism to encode interactions with environment to braiding.

Ho realizes the importance of water-protein interaction (see article *Proteins secret water music in nanospace* at http://tinyurl.com/ybdrrtft) [I110]. Ho dares also to speak about homeopathy and water memory (see *Quantum Coherent Water Homeopathy* at http://tinyurl.com/ydhwlbz7 [I110]). The TGD counterpart is the vision about cellular and molecular "seasons". External energy feed melts the "ice" formed by ordered water around globular proteins. This leads to new conformations and protein aggregation. This process also updates topological quantum programs by inducing time-like braiding changing space-like braidings of the perturbed part of the system with its complement.

Ho also emphasizes the importance of liquid crystal phases in biology. Liquid crystals are associated with cell membranes, cytoskeletal and muscle proteins, collagen and other connective tissue macromolecules, and also DNA in chromosomes [?] Ho assigns morphogenic fields with them (see *Liquid Crystalline Morphogenetic Field* at http://tinyurl.com/c4udjsm [I111]). Ho has introduced "Quantum Jazz" as a wonderful metaphor for what Bohm would have called active information and I call negentropic entanglement making possible highly correlated states in which particles are effectively free. Ho has proposed that these liquid crystals act as a holographic medium and based the proposal on the effects of polarized light [?] In TGD framework also magnetic flux tubes would be involved. Flux tubes would connect the basic units of liquid crystals to those of other liquid crystals. DNA nucleotides to lipids of nuclear or cell membrane [K6] (see http://tinyurl.com/ybyscdpt).

Space-like braiding is modified by liquid chrystal fluid flows defining time-like braidings (dance metaphor). Liquid crystals plus magnetic flux tubes could serve as the holographic medium storing dynamical patterns to spatial patterns and therefore defining also fundamental memory representations. The sensitivity of liquid crystal state and therefore of braiding to various parameters

such as em fields, temperature and pressures changes, hydration, pH, concentrations of various ions makes braiding an ideal mechanism for making living matter a hologram substrate.

Also topological quantum computation like processes would become possible. The fractality crucial for holography would correspond to the possibility of having flux tubes within flux tubes within.... In other words, one would have hierarchical braiding. Braids would decompose to braids which are braided in turn. As a matter fact, this braiding is central element of the dynamics of TGD Universe, not only of TGD inspired biology.

I have commented some of the articles of Mae Wan-Ho in the chapter *TGD inspired model* for nerve pulse (see http://tinyurl.com/y8e5oqkm) of [?]see the article *Can Water Burn*? at http://tinyurl.com/y7pjv6eh [D18]) and in the chapter *Quantum gravity, dark matter, and* prebiotic evolution (see http://tinyurl.com/y8gr9enm) of [K120].

8.13.2 Peter Gariaev

Peter Gariaev and his group have done a lot of pioneering work in bio-electromagnetism and the notion of wave DNA is due to him. The findings of Gariaev's group include the rotation of polarization plane of laser light by DNA [I52], phantom DNA effect [I53], the transformation of laser light to radio wave photons having biological effects [I54], the coding of DNA sequences to the modulated polarization plane of laser light and the ability of this kind of light to induce gene expression in another organisms provided the modulated polarization pattern corresponds to an "address" characterizing the organism [I52], and the formation of images of what is believed to be DNA sample itself and of the objects of environment by DNA sample in a cell irradiated by ordinary light in UV-IR range [I86]. The chapter "Model for the findings about hologram generatg properties of DNA" (see http://tinyurl.com/y9ughr5f) [K1] of book "Genes and Memes" represent an article written in collaboration with Peter Gariaev and published in DNADJ (DNA Decipher Journal) in January 2011. If the interpretation of the experimental data is correspond then dark matter at magnetic flux body assignable to DNA sample has been photographed. What would happen that incoming photons leak to the dark flux tubes in a phase transition changing the value of Planck constant, are reflected from the dark matter and transform back to ordinary photons generating the picture in the film.

"Quantum Model for remote replication" (see http://tinyurl.com/ybvosy7h) [K149] is second article written together with Peter Gariaev. There are three experimental guidelines: the phantom DNA [I53] identified as dark nucleon sequences in TGD framework and the evidence for remote activation of DNA transcription [I52] - both discovered by Gariaev's group - are assumed as the first two key elements of the model. The remote replication of DNA suggested by the experimental findings of Montagnier's group serves as a further guideline in the development of the model. Also the results of the latest experiment of Gariaev's group in many respects similar to that of Montagnier's experiment but differing in certain crucial aspects from it are used as input.

Polymerase chain reaction (see http://tinyurl.com/ybv6mn51) (PCR) is the technique used in the experiments of Montagnier's group [I22] and later in somewhat modified experiment by Gariaev's group involving irradiation of the second test tube by laser light. DNA polymerase catalyzes the formation of DNA from existing DNA sequences serving as a template. Since the catalytic interaction of DNA polymerase takes place with already existing DNA sequence, the only possibility is that first some conjugate DNA sequences are generated by remote replication after which DNA polymerase uses these sequences as templates to amplify them to original DNA sequences. Whether the product consists of original DNA or its conjugate can be tested.

In TGD inspired quantum biology the representations of genes in terms of temporal patterns of em radiation could be in central role. TGD suggest 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 would mean 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. The basic problem of the model is how to the gene coded as a temporal field pattern could activate corresponding gene. It seems that the solution of this problem requires that also linear spatial pattern matters. A possible realization would be as planar sheets of magnetic flux tubes emerging from sender DNA and attaching to the target DNA and carrying the radiation. Remote replication would take place only if resonance condition for the frequencies depending on nucleotides is satisfied for each flux tube. Note that DNA as topological quantum computer relies on similar flux tube structure.

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 [K49]. 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 exists many representations of DNA. Also the model for DNA as topological quantum computer [K6] proposes a non-standard representation of the code.

The model inspires the proposal that the magnetic body of a polar molecule codes for it using dark nucleon sequences assignable to the hydrogen bonds between the molecule and surrounding ordered water layer. Quantum antenna mechanism would allow the immune system to modify itself by developing ordinary DNA coding for amino-acids attaching to and thus "catching" the polar molecule. The mechanism could be behind water memory and homeopathic healing. Every polar molecule in living matter would have dark nucleon sequence or several of them (as in the case of amino-acids) serving as its name. This would also associate unique dark nucleon sequence also with the magnetic body of DNA so that "DNA-dark DNA" association would be automatic. Same applies to mRNA and tRNA and amino-acids. The general idea is therefore that symbolic dynamics emerges already at the molecular level: the dark DNA sequence serving as a "name" of the molecule to high extent determines the dynamics just as in human society.

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.

8.13.3 Luc Montagnier

The article "DNA waves and water" by L. Montagnier, J. Aissa, E. Del Giudice, C. Lavallee, A. Tedeschi, and G. Vitiello [I61] has created quite a furor even before its publication. The article was preceded by article [I60], whose results led to my own proposal about the existence of new kind of representation of DNA in water [L5] and the recent article indeed suggests the existence of a new kind nano-scale represention of DNA besides electromagnetic representation of the code, which was also suggested for years ago by the group of Peter Gariaev [I52] and also in TGD framework [K61]. The article "DNA waves and water" (see http://tinyurl.com/y8buy89k) [L17] discusses TGD based explanation of the findings.

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.

The model explaining remote replication would apply also to the findings of Montagnier. The essential elements would be sheets formed by flux tubes emerging from DNA crucial also in the model of DNA as quantum computer and nucleotide dependent resonance condition satisfied for each flux tube allowing DNA portion to active only similar DNA portion.

The findings of Montagnier demand that the genetic code is represented somehow by dark photons, presumably dark photon frequencies. How genetic code could be represented in terms of frequencies? The TGD based model of music harmony [L32] [K102] (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.

8.13.4 Rupert Sheldrake

Rupert Sheldrake is very interesting thinker whose basic idea is that even genetic expression is more like a habit. Even the manner how crystallization takes place could be a habit. In TGD framework the 4-dimensional character of geometric existence and zero energy ontology in which quantum states are pairs of positive energy states assignable to the two light-like boundaries of causal diamonds conforms with Sheldrakes views (see the article "Sheldrake's Morphic Fields and TGD View about Quantum Biology" at http://tinyurl.com/y79kxbua).

The basic idea of Sheldrake that Nature would have habits just as we do is probably one of those aspects which generate most irritation in physicalists believing that Nature is governed by deterministic laws with classical determinism replaced with quantum statistical determinism. Sheldrake is one of those very few scientists able to see the reality rather than only the model of reality. Morphic resonance would make possible to establish the habits of Nature and the past would determine to high extent the present but on organic manner and in totally different sense as in the world of physicalist.

8.13.5 Seth Lloyd On Quantum Life

The notion of quantum biology is becoming accepted notion although Wikipedia contains still nothing about its most important application (photosynthesis). I can be proud that I have been a pioneer of quantum biology for about two decades. TGD remains still one of the very few theories leaving the realm of standard quantum theory and suggesting besides the new view about space-time a generalization of quantum theory involving in an essential manner quantum theory of consciousness based on the identification of quantum jump as moment of consciousness. The new view about quantum theory involves a refined view about quantum measurement based on Negentropy Maximization Principle (NMP) [K80] identified as the basic variational principle and zero energy ontology (ZEO) replacing ordinary standard energy ontology. The new view providing new vision about the relationship between subjective time and geometric time, about the arrow of time, and about second law.

The hierarchy of Planck constants having as space-time correlate effective (or real -depending on interpretation) *n*-sheeted coverings of 8-D embedding space (or space-time) with $h_{eff} = nh$ defining the value of (effective) Planck constant. p-Adic physics as physics of cognition is essential part of theory and together with the hierarchy of Planck constants closely related to the notion of negentropic entanglement characterizing living matter. Negentropic entanglement is maximal involving two-particle case tge entanglement of *n* states characterized by $n \times n$ unit matrix with *n* identified in terms of h_{eff} . Also maximal *m*-particle entanglement with $1 < m \le n$ is possible and one can write explicit formulas for the entangled states relating closely to the notion of exotic atom introduced earlier. The hierarchy of Planck constants as associated with dark matter so that dark matter is what makes living matter living in TGD Universe.

The concepts of many-sheeted space-time and topological field quantization imply that the concept of field body (magnetic body) becomes a crucial ew element in the understanding of living matter. Non-locality in even astrophysical scales becomes an essential piece of the description of living matter. Remote mental interactions making possible communication between biological and magnetic bodies become standard phenomena in living matter. The reconnection of magnetic flux tubes and phase transitions changing the value of h_{eff} and thus changing the length of magnetic flux tubes become a basic piece of biochemistry. Various macroscopic quantum phases such as dark electronic Cooper pairs and of protons and even ions as well as Bose-Einstein condensate of various dark bosonic objects with large value of h_{eff} are also central. They are associated with magnetic flux tubes).

TGD implies a new, still developing, view about metabolism. Magnetic body as a carrier of metabolic energy and negentropic entanglement (see Fig. http://tgdtheory.fi/appfigures/cat.jpg or Fig. ?? in the appendix of this book) allows to understand the deeper role of metabolism in a unified manner. The notion of high energy phosphate bond assigned to ATP is one of the poorly understood notions of biochemistry. As a matter fact, all basic biomolecules are carriers of metabolic energy liberated as they are broken down in catabolism. It is usually thought that the covalent bonds containing shared valence electron pair between atoms involved carries this energy and that covalent bond reduces to standard quantum theory. TGD challenges this belief: covalent bond could in TGD framework correspond to magnetic flux tube associated with the bond having considerably larger size than the distance between atoms: similar picture has already earlier emerged in the model of nuclei as strings with colored flux tubes connecting nucleons and having length scale much longer than nuclei [L3]: this model also explains [K82] the puzzling observation that protonic charge radius seems to be somewhat larger than predicted [C5].

The metabolic energy quantum would be associated with large h_{eff} valence electron pair being identifiable as cyclotron energy in endogenous magnetic field for which the pioneering experiments of Blackman [J23] suggests value $B_{end} = .2$ Gauss as the first guess. Of course, entire spectrum of values coming as power of two multiples of this field strength can be considered. This would require rather high value of h_{eff}/h of order 10^8 . Reconnection of flux tubes would make possible to transfer these electron pairs between molecules: actually a piece of flux tube containing the electron pair would be transferred in the process. This view allows to unify the model of metabolism with the view of DNA-cell membrane system as topological quantum computer with DNA nucleotides and lipids (or molecules assigned with them) by flux tubes.

Seth Lloyd represents three examples about situations in which quantum biology seems to be a "must": photosynthesis, navigation of birds, and odour perception. Photosynthesis represents the strongest and most quantitative support for quantum biology. Navigation and odour perception suggest strongly quantum theory model but leave the details of the model open.

I have applied TGD to numerous situations during years and also discussed simple TGD inspired models for all these three phenomena. The following represents briefly the core of Lloyd's talk and comparison with TGD based views. I do not of course have access to the data basis and can represent only a general vision rather than detailed numerical models. I share Lloyd's belief that quantum models provide the only manner to understand the data although models as such are not final. The authors of course want to publish their work and therefore cannot introduce explicitly notions like high temperature super-conductivity, which I believe are crucial besides purely TGD based concepts. What is however good that the models start from data and just look how to explain the data in quantum approach. Data lead to assumptions, which are

not easy to defend in the framework of standard quantum theory. For instance, the presence of long-lived entangled pairs of electrons and electron and hole with wave functions possessing rather long coherence length and somehow isolated from entanglement destroying interactions with the external world emerge from the data. In TGD large value of h_{eff}/h and associated negentropic entanglement justifies these assumptions.

Photosynthesis

The incredible effectiveness of the first step of the photosynthesis after photon absorption [J56] is one of the key points of Lloyd in this talk (http://tinyurl.com/yadbjx2x). The organisms living deep under the surface of ocean are able to gather their metabolic energy using only the visible photons of black body radiation, whose typical photon energy is much lower than that of metabolic energy. In human eyes there is even mechanism preventing the detection of less than five photons at time.

The first step of photosynthesis after the capture of photon by harvesting antenna proteins has been a long standing mystery and here only quantum mechanical approach seems to provide the needed understanding. The light harvesting antenna proteins can be visualized as small disk like objects and are associated with a membrane like structure - so called thylakoid membrane similar to cell membrane. The absorption creates what is known as exciton - electron-hole pair, which is most naturally singlet. Photon has spin so that the exciton must have unit angular momentum. After its creation the electron of the exciton reaches by a random walk like process the reaction centre. From the reaction centre the process continues as a stepwise electron transfer process leading eventually to the chemical storage of the photon energy.

The capture of photon occurs with some probability and also the process continues from reaction centre only with probability of about 5 per cent. The process with which the electrons reaches the reaction centre is however amazingly effective: effectives is above 95 per cent. This is mysterious since fort the classical random walk for exciton between the chromophores the time is proportional to the square root of distance measured as number of neighboring chromophores along the path.

The quantum proposal is that exciton is spin singlet state - this minimizes the interactions with photons - and performs quantum (random) walk to the reaction centre. The model assumes only experimental data as input and all parameters are fixed. Temperature remains the variable parameter. One can consider two extreme situations. At low energy limit the random walks tends to be stuck since external perturbations (mostly thermal photons) inducing the random walk process are not effective enough and quantum walk becomes so slow so that the exciton decays before it reaches the reaction centre. At high energy limit the thermal perturbations destroy quantum coherence and classical random walk results so that the efficiency becomes essentially zero. There is a temperature range where the transfer efficiency is near unity and time for reaching the reaction centre relatively short. This range has as midpoint room temperature.

If I have understood correctly, the model accepts as experimental facts the rather long lifetime of the exciton - few nanoseconds. In quantum-computerish this assumption translates to the statement that exciton belongs to a de-coherence-free subspace so that external perturbations are not able to destroy the exciton too fast. Second assumption is that the exciton is de-localized over a ring ling like structure of size scale of 7 Angstroms (actually there are two rings of this kind, inner and outer and the wave function is assumed to be rotationally symmetric for the inner ring). This de-localization increases the probability of transfer to neighboring chromophore so that it is proportional to the square N^2 of the number N of chromophores rather than N. The technical term expressing this is concatenated quantum code.

Skeptic would probably claim that coherence and stability of coherence are the weak points of the model. In TGD framework the assumption that electron-hole pair is negentropically entangled would guarantee its long life time. The reason is that NMP [K80] favors negentropic entanglement. Negentropic entanglement corresponds to entanglement associated with *n*-sheeted effective covering of embedding space and *n* has interpretation in terms of effective Planck constant $h_{eff} = nh$. The naïve guess is that coherence scale for the wave function of exciton scales up by factor *n* or \sqrt{n} . This entanlgement need not have anything to do with spin but could relate to large \hbar .

I have earlier considered a slightly different proposal [K69]. Instead of exciton the negentropically entangled system would be Cooper pair of dark electrons. Note that the negentropic entanglement need not relate to the spin but to the *n*-fold covering although it could be assigned with spin too in which case the state would be spin singlet. The motivation came from the fact that the transfer of electrons to the reaction centre takes as pairs (http://tinyurl.com/ycrj3zqe). The TGD inspired interpretation of electron pair would be as dark Cooper pair. Two electron pairs would come from the splitting of two water molecules to O_2 , 4 protons and two electron pairs, and they would end up to P680 part of photosystem II (680 refers to maximally absorbed wavelength in nanometers) and from here to P680^{*} as two pairs. This mechanism would require that the Cooper pairs absorbs the photon as single particle. In the case of dark Cooper pairs this might be naturally true. If this requires exchange of photon between the members of the pair, the rate for this process is of the order α^2 lower.

Avian navigation

Second topic discussed by Seth Lloyd is avian navigation (http://tinyurl.com/zwdso). The challenge is to understand how birds (and also fishes) are able to utilize Earth's magnetic field in order to find their way during migration. In some cases the magnetite in the beak of the bird guides the way along magnetic field lines by inducing magnetic force, and the process can be understood at least partially. Consciousness theorist could of course wonder why these animals find year after year their exact birth place.

Robins however represent an example not so easy to understand. There are three input facts:

- 1. Robins are able to detect the orientation of B_E but not its direction. They can also detect the angle between orientation and vertical to the Earth's surface and from this to deduce also the direction of B_E .
- 2. Blue or green light is necessary for the successful detection of the orientation.
- 3. Oscillating em field with frequency of order MHz makes the robins totally disoriented.

The only model that seems to be able to explain the findings is that long-lived entangled pairs of electrons are created by the photon provided their energy is high enough. For red light the energy is 2 eV and is not yet quite enough. This suggests that the electrons originate from a pair of molecules or atoms of single molecule. It is not known what the molecules in question could be. The electrons of the pair are spinning in the magnetic field and this is suggested to cause the decay of the pair and second member (why not both?) of the pair would contribute to a current giving eventually rise to nerve pulse pattern.

Entangled long-lived electron pair should be created. Long lifetime is the problem. The proposed mechanism brings in mind the TGD based variant for the light harvesting mechanism of photosynthesis. Universality suggests that long lived dark negentropically entangled Cooper pairs are generated in both cases so that light harvesting is in question in both cases. These pairs assignable to membrane structures in both cases in turn would generate a supra current giving eventually rise to a generation of nerve pulses in the case of navigation and to electron transfer process in the case of photosynthesis. If the same mechanism is involved in both cases, the extreme effectiveness of this light harvesting process could make it possible for the birds to navigate even in dark. Electron has cyclotron frequency of about 1.5 MHz in the Earth's magnetic field and this makes easy to understand why oscillation with this frequency (resonance) induces disorientation by forcing the spinning of the dark Cooper pairs.

Why the energy of photon creating the dark electron Cooper pair should correspond to visible light? Cyclotron energy scale for the ordinary value of Planck constant is extremely small and corresponds to frequency in MHz range. For visible photons the frequency by order of magnitude 10^8 higher. Does this correspond to the value of h_{eff} ? Similar order of magnitude estimate follows from several premises. If the scaling of h by n corresponds roughly to the scaling of p-adic scale by \sqrt{n} , one would have roughly 10^{15} -fold (effective) covering of embedding space which looks rather science-fictive! For electrons this would imply size of order cell size if dark scale corresponds to the p-adic scale. If the electrons are originally in bound states with binding energy of order eV, the value of h_{eff} could be much lower.

I smell the quantum

Quantum detection of odours was the third topic in Lloyd's talk. For decades it was believed that odor perception is based on lock and key mechanism. Human has 387 odour receptors and this would be the number of smells too. It has however turned out that humans can discriminate between about 10^4 smells and Luca Turin and his wife have written a book giving a catalogue of all these smells. It is clear that lock key mechanism is correct but something else is needed in order to understand the spectrum of odors.

The key observation of Turin is that the smells seems to be not purely chemically determined but is different for molecules consisting of atoms differing only by the weight of nucleus and thus being chemically identical. Therefore the vibrational spectrum of the molecule, which is typically in infrared, seems to be important. The proposal of Turin is that the process of odour perception involves the tunnelling of the vibrating electron from odour molecule. This tunnelling can be assisted by absorption of phonon coming from the receptor with frequency which corresponds to fundamental vibrational frequency or its multiple. The model has been tested in several cases. The latest test described by Lloyd is the one in which hydrogen in some molecule is replaced with deuteron, which is twice as heavy so that the vibrational frequency is reduced by a factor $1/\sqrt{2}$. Fruit flies took the role of odour perceivers and it turned out that they easily discriminate between the molecules.

I have considered earlier a somewhat different quantum model for odour perception by starting from the pioneering experimental work of Callahan [I117], which led him to conclude that in the case of insects odour perception is "seeing" at infrared wavelengths. Infrared wavelengths correspond to vibrational energies for molecules so that this brings in the dependence on the square root of the inverse of the mass of the odorant and predicts that chemically identical molecules containing only different isotopes of atoms smell differently.Frequencies are same as in the model of Turin. Instead of phonons IR photons would play the key role serving as passwords exciting particular cyclotron state at particular magnetic tube. Similar mechanism could be at work in the case of ordinary vision.

8.13.6 Orch-Or Theory Of Penrose And Hameroff And New Experimental Findings About Microtubules

The latest news in quantum biology is the claim about corroboration of the Orch OR theory of Penrose Hameroff (see http://tinyurl.com/ybgaeoeu) [J1]. To my humble opinion the news suffer from rather heavy hyping. If the observation of the group lead by Anirban Bandyopadhyay about detection of quantum vibration in microtubule scale (their lengths vary up to 50 μ m) can be replicated, one can speak about breakthrough in quantum consciousness. The results do not however prove Orch OR, which involves poorly defined vision about quantum gravitational description of state function reduction so that most predictions are just order of magnitude estimates relying on Uncertainty Principle.

The biological half of the theory relies on microtubules and for this side of the theory the claimed finding would of course be a victory. Indeed, there is a meeting in Amsterdam devoted to Orch OR theory of consciousness motivated by this finding (http://tinyurl.com/zwayvl2). Unfortunately, I could not find any article about the findings of Bandyopadhyay in web. I managed however to find two years old Youtube talk of Bandyopadhyay summarizing earlier experimental results supporting the vision about microtubules as macroscopic quantum systems (http://tinyurl.com/ze366ny) [J10] to be discussed below.

The findings reported in the talk give support for the general TGD inspired view about TQC and allow rather detailed model in the case of microtubules. The idea is that flux tubes form a 2-D coordinate grid consisting of parallel flux tubes in two different directions: the guess that they could consist of helical Fibonacci flux tubes and their mirror images is not however convincing. Crossing points would be associated with tubulins and the conformational state of tubulin could define a bit coding whether the braid strands defining coordinate lines are braided or not (swap or not). In this manner any bit pattern at microtubule defines a particular TQC program. If also conformations are quantum superposed, one has "quantum-quantum computation". It however seems that conformation change is irreversible chemical reaction [J52] so that this option is not feasible.

The TGD inspired modification of the proposal in terms of flux tube coordinate grids making possible TQC architectures with tubulin dimers defining bits defining in turn TQC program looks more plausible to me. Coordinate grids can be fixed on the basis of the experimental findings and there are 8 of them. The interpretation is in terms of different resolutions. The grids for A and B type lattices are related by 2π twist for the second end of the basic 13-unit for microtubule. An attractive interpretation for the resonance frequencies is in terms of phase transitions between A and B type lattices. If A type lattices can be generated only in phase transitions induced by AC stimulus at resonance frequencies, one could understand their experimental absence, which is strong objection against the Penrose-Hameroff model.

This would fit very nicely with the general vision about frequencies as passwords inducing not only directed attention but activities in target - also TQCs! The increase of Planck constant could be associated with the phase transition to A-phase making possible high T_c dark superconductivity for which evidence is observed! One can even deduce estimates for $h_{eff}/h = n$ if one requires that AC photons have energy above thermal threshold: $n = h_{eff}/h = f_{visible}/f_AC$ would be the estimate. For bio-photon energies one would obtain something like $n \simeq 10^8 - 10^9$, which pops up in different contexts in TGD framework.

This picture generalizes in the fractal universe of TGD. One can form layers of 2-D coordinate grids and connect them by vertical flux tubes to obtain 3-D grid defining TQC. The brain is known to have grid-like architecture and neurons could by quantum computation produce bit/qubit defining swap or not/superposition of swap and not-swap for a larger scale TQC. One would have fractal of TQCs. One can even think 4-D grids in Euclidian space-time regions with 6 bits defining the swaps at each crossing point: could this have something to do with the genetic code?

A further idea is that 1-braid TQC generalize in a natural manner to 2-braid TQC in TGD framework (for 2-braids see [K66]. The knotting occurs for string world sheets defining the orbits of braid strands - say magnetic flux tubes idealized to strings. In the case of microtubules this option suggests itself: the emergence of MTs could have meant emergence of 2-braid TQC and the increase of abstraction level in the information processing. Note that 2-braiding is possible only if string worlds sheets "live" in 4-D space-time: for super strings living in higher-D space-time this is not possible.

In TGD Universe one could look at the situation also from the point of view of metabolism.

- 1. Dark particles quite generally have higher energies than ordinary particles. For instance, atomic bindings energies are scaled down like $1/h_{eff}^2$ and cyclotron energies scale like h_{eff} . The generation of dark particles with increased value of h_{eff} requires therefore energy identifiable as metabolic energy. The increase of h_{eff} creates quantum coherence in longer length scale in turn inducing coherence of living matter. $h_{eff}/h = n$ also serves as a kind of IQ for the system. The larger n is, the better ability the system has to generate negentropic entanglement.
- 2. In Bandyophyay's experiments AC voltage feeds metabolic energy. Microtubules of type A generated in the process are ordered in longer scale than microtubules of type B. In living matter this energy feed is due to the radiation generated by other parts of living system. Note that the basic objection abgainst Penrose-Hameroff theory is that in vitro only microbutules of type B are possible.

Penrose-Hameroff theory

Approximately two decades ago Penrose and Hameroff proposed a model that they called Orchestrated Objective Reduction (Orch OR) [J70]. Besides the highly speculative quantum gravity related ideas, the model assumes that microtubules are quantum coherent systems essential for consciousness. For the importance of microtubules one can find a lot of qualitative support. A I believe that microtubules are important for consciousness and I have developed ideas about the role of microtubules [K91]. Personally, however, I find it difficult to believe in the reduction of consciousness to microtubular level, but see microtubules as one particular layer in the hierarchy of conscious entities. Personally, I would prefer fractality over the naïve length scale reductionism.

Many objections [J52] against the biological feasibility of Orch OR (http://tinyurl.com/ nx4vevv) [J70] have been raised. For the latest response of the authors to the criticism see [J69]. There are two basic challenges: one should formulate precisely what Orch OR really means and be able to identify the qubit.

- 1. The basic vision about quantum superposition of space-time geometries gives rise to consciousness as something analogous to quantum computation. State function reduction would thus reduce to a mechanism rather than being something irreducible. Most quantum physicists would disagree about this. The quantum superposed geometries would be protein conformations. Since there is no theory of quantum gravity, the proposal boils down to the ad hoc estimate for the time τ for Orch OR to take place claimed to be $\tau = \hbar/E_G$, where E_G is the difference of gravitational energies for the superposed geometries. The estimates favor nuclear scale 5 fm and one needs a coupling between nano-scale physics of electrons and physics nuclei and London forces are suggested to be responsible for this coupling. It deserved to be mentioned that the gravitational energy for a blog of water with radius around 10^{-4} meters - the size scale of large neuron - is about Planck mass so that gravitation and biology might relate. In my own proposal involving large gravitational Planck constant assigned to space-time sheets mediating gravitational interaction, Planck mass might serve as a threshold above which large values of Planck constant would emerge [K117, K93].
- 2. Concerning the identification of qubit there is a long list of suggestions. The superposition of tubulin conformations was one of the first proposals. Reimers [J52], who has criticized heavily Orch-OR proposal, reports that irreversible chemical reaction is responsible for selecting conformation so that quantum superpositions would not make sense. Conformational switching could however be involved with classical computational aspects of biological information processing and Hameroff has proposed before Orch OR that microtubules could act as classical cellular automatons.

Also other proposals for qubit have been made. Quantum fluctuations generating London force between electric dipoles could somehow give rise to qubits. Also magnetic dipoles, nuclear spin, AC current flow, and synergistic modes have been mentioned. Also the identification of qubit as a helical conduction pathway has been proposed ("Oscillating London force dipoles in resonance rings in helical pathways through microtubule lattices"). It is difficult to imagine what the two superposed states defining qubit would be. For instance, could qubit correspond to electron current running in two different directions and is quantum superposition possible at criticality for a phase transition inducing the change of the current direction? For this option the information storage capacity of microtubule would be rather modest. In also difficult to see the claimed connection with topological quantum computation since braiding gives rise to entanglement between states at the ends of the braids.

Orch OR proposal involves several interesting ideas probably relevant for quantum consciousness.

1. Aromatic rings have probably some deep role in quantum consciousness. For instance, most psychoactive biomolecules and also DNA and three amino-acids contain them. Hameroff and Penrose trace this role to London force between aromatic rings and quantum fluctuations making them qubits. I am unable to imagine what the exact proposal is. In any case, what is known is that electrons at aromatic rings are de-localized.

Comment: My own humble proposal is that electrons could be further de-localised at magnetic flux tubes in longer scales and make cyclotron BE condensates of dark electrons or their Cooper pairs possible. They would make possible the coupling between receptor-information molecule complex and magnetic bodies at various levels of hierarchy. Hierarchy of Planck constants and negentropic entanglement suggests the existence of a new kind of state consisting of electrons (that is fermions) but analogous to Bose-Einstein condensate.

- 2. The idea about insulation provided by hydrophobic pockets of proteins against fluctuations destroying quantum coherence is nice and it would be natural to put aromatic rings into these pockets.
- 3. The needed long value of Orch OR de-coherence time τ (originally assumed to correspond to 40 Hz thalamocortical resonance frequency) is one of the problems of Orc OR and the recent

discovery of EEG like oscillations in kHz range [J58] is claimed to make the situation more tolerable.

Comment: Fractal hierarchy of EEGs mediating communications between parts of biological body and corresponding magnetic body is basic prediction of TGD and the observation seems to provide evidence for this prediction.

4. Reimers *et al* challenges [J53] also Fröhlic Bose-Einstein condensation [J68] and claims that according to his own simulations the resulting state is extremely incoherent [J53]. There are however models which give Bose-Einstein condensation [J8] and the in [J10] the experimental findings about assembly of microtubules are interpreted as Fröhlic condensation. The frequency inducing the condensation would be however 3 orders of magnitude lower than predicted by Fröhlich.

There is a further puzzling result (http://tinyurl.com/y7f2r93o) [J46] in conflict with the assumption of Orch OR that brain microtubules are dominantly so-called A-type tubules. Brain microtubules re-assembled in vitro form lattices of type B and for them the lattice must have surface discontinuities. This makes sense for microtubules which are partially fused together as in the structures consisting of cylinder whose surface is formed by 9 units consisting of 3 microtubules glued together along their sides. This would not allow Fibonacci helices proposed by Penrose and Hameroff to serve as conducting pathways defining the analogs of braid strands in their model for microtubule as topological quantum computer (TQC) unless one is ready to give up helical symmetry. One way out of the difficulty would be that vitro results do not hold in vivo but Kikkawa *et al* has shown that all in vivo microtubules have lattice of type B (http: //tinyurl.com/ybnxymuw) [J39].

The above mentioned article concludes that only the lattice B is realized in nature. This lattice does not possess helical symmetry. After each full turn along sequence α or β tubulin sequence there is a shift as the figure 2 of the article demonstrates: this discontinuity is called seam in the article. Furthermore, these helices can be said to have periodicity 5. The helix-like curve satisfies the condition $z = 4a\phi/2\pi$ and the n^{th} tubulins along vertical is located at z(n) = na, a the size of the tubulin. For $\phi = 2\pi$ one has $\Delta z = a$ rather $\Delta z = 0$ as figure 2 of the article shows. This discontinuity could have some important biological meaning.

Hameroff, Nip, Porter, and Tuszynski have an article about microtubules as topological quantum computation written in 2002 [J36]. They do not give any justification for why the conduction pathways should correspond to Fibonacci numbers but the article by Hameroff represents evidence that the important certain amino-acids crucial for consciousness inside tubulin molecules are located along the Fibonacci conduction pathways (http://tinyurl.com/yb5odlmn) [J36].

2011 Hameroff and Penrose considered the possibility that microtubules could perform topological quantum computation. The proposal of Penrose and Hameroff (http://tinyurl.com/ yb5odlmn) [J36] assumes realization of braiding in terms of helical braids strands assignable to A-type microtubules (which according to experimenters do not exist in brain and - as it seems in living matter in general). In the simplest realization the strands are parallel to each other and have horizontal periodicity characterized by 13 tubules. Also Fibonacci pathways with horizontal periodicity of 3, 5, and 8 are Fibonacci pathways. The strands with different periodicities can intersect and can therefore be braided. One can also construct left- and right handed variants of the strands and left- and right-handed strands intersect periodically with a period of 13. The experiments discussed in [J10] however suggest a different kind of braidings.

In the intersection points braiding (swap) operation could be realized meaning that first strand goes either over or below the second one. Gupta and Hameroff suggests that MAPs are responsible for this kind of swap and thus define the fundamental quantum gates for TQC (http://tinyurl.com/ycohz259) [J67]. Of course, also more complex gates can be imagined but swap is enough to build universal TQC. Official biology assigns to MAP many other functions associated with MAPs but also this function can be imagined. Penrose and Hameroff have also considered the possibility that topological qubits are represented in terms of quantum superpositions of helical pathways with 13-periodicity characterized by the gap between neighboring pathways.

The identification of Bandyopadhyay for conduction pathways

In his Youtube talk Anirban Bandyopadhyay (http://tinyurl.com/ze366ny) [J10] discussed an identification of conduction pathways different from that of Penrose and Hameroff. In [J64] Gosh, Sahu, and Bandyopadhyay argue for evidence for massive global synchronization in brain and claim that experimental findings support the Penrose-Hameroff theory. In the article "Atomic water channel controlling remarkable properties of a single brain microtubule: correlating single protein to its supramolecular assembly" [J54] it is reported that ordered water inside microtubule is necessary for the conduction inside microtubule. According to the same article the tubulins inside microtubule has same energy levels in chemical energy range as isolated tubulins which suggests that the mechanism binding tubulins to form MT is not chemical. In the article "Multi-level memory-switching properties of a single brain microtubule" [J55] it is reported that the hysteresis curve for current along MT as function of voltage is ideal square curve meaning that there is no dissipation involved with the change of the current direction. This would make MT as an ideal memory device. Whether Penrose/Hameroff have in mind the use of current direction as qubit remains unclear. In video talk Bandyopadhyay refers also to these results.

I consider only the general proposal discussed in video lecture here: the Youtube representation gives concrete illustrations of conduction pathways.

- 1. It is assumed that there are two kinds of hexagonal tubulin lattices labelled as A and B. As found there is strong evidence that A-type tubules do not exist stably. For both types the tubulin dimers defining dipoles are nearly axial and define candidates for conduction paths with winding periodicity of 13 tubulin dimers. For B type one has rows made of α or β type tubulins along with α and β have effective periodicity of five if one accepts discontinuity at after 2π rotation. One might think that this dictates the choice of the candidates for the conduction paths to consist of sequences of $\alpha - \beta$ dimers: for these sequences are along the microtubule. If hops occur between α and β this assumption is natural. The proposed pathways are however more general and - as it seems to me - based on rather ad hoc mathematical rule.
- 2. The notion of helical conduction pathway is the starting point. For B-type tubules this notion must be modified. Presumably the criterion for what it is to be a helical pathway is that they are straight-lines connecting nearest neighbors to each other- this is natural if conduction is identified as hopping between neighboring tubulin molecules. The position of each pathway represented by a value of discrete dynamical variable replacing spin as representation of qubit -essentially the angle $\phi = n \times 2\pi/13$ is in question. There are 13 different values for ϕ . For A-type conducting pathways the condition that one has $\alpha - \beta$ sequence very probably gives the claimed pathways with periodicity 13. One can ask whether the pathways of type A are obtained by twisting the pathways of type B at the second end by 2π and whether living systems could be able to perform this twist to achieve phase transition between two states of the microtubule.
- 3. Instead of single pathway one considers groups of parallel pathways consisting of translates of a fixed pathway with a fixed gap $\Delta \Phi_{gap} = n_{gap} 2\pi/13$ along the circumference of microtubule. I failed to understand the motivation for this: maybe the idea is that the additional degree of freedom makes possible the analog of spin degree of freedom as angular position of the pathway. One could also consider the possibility that the translates of a pathway define a braid: this braid would be however trivial since the pathways are parallel. If I have understood correctly, topological qubits would be represented as quantum superpositions of helical conduction pathways with same gap $\Delta \phi = n_{gap} \times 2\pi/13$ between neighboring pathways. This is not what TGD suggests.
- 4. By n = 13 modulo arithmetics it can that the series of pathways with $n = kn_{gap} \mod 13$, $k = 1, 2, \ldots$ generates additional gaps. One says that the decomposition occurs. The addition of translated parallel pathways can also lead to a pair of pathways with $n_{gap} = 0$ or $n_{gap} = 1$ in which case pathways overlap or touch. This is not allowed. What this means physically is unclear to me. One could also avoid touching simply by allowing only the translates to be such that $kn_{gap} \leq 13$ holds true: even weaker condition can guarantee this.

Consider first what one obtains for A-type microtubules.

1. The construction rule gives for $n_{gap} \in 1, 2, 3, 4, 6, 12$ many secondary gaps, in particular $n_{gap,new} = 1$ so that "don't touch" rule is violated. For $n_{gap} \in \{5, 7, 8, 9, 10, 11, 13\}$ only 1 or one secondary gap or no secondary gap is obtained. The decompositions of primary gaps are

 $5 \to (5,3) \ , \ \ 7 \to (7,6) \ , \ \ 8 \to (8,5) \ , \ \ 9 \to (9,4) \ , \ \ 10 \to (10,3) \ , \ \ 11 \to (11,2) \ , \ \ 13 \to 13 \ .$

2. One can form from these collections of parallel pathways more complex collections as unions. Only unions for which "don't touch" rule is satisfied. This leaves for A-type microtubules 4 groups of pathways characterized by four values of n_{gap} each. The 4 groups of 4 of n_{gap} values which can co-exist without breaking the basic rule are

Here only the generating gaps are listed. For instance, the (8, 5, 10, 13) decomposes to (8, 5, 3, 10, 13).

- 3. There is a problem: these parallel pathways do not have intersections and therefore cannot form braids unless also their mirror images are allowed or one introduces additional group of pathways, which could be called transversal.
- 4. One does not obtain Fibonacci conduction pathways with periodicities 3, 5, 8 for A-types microtubules suggested by Penrose and Hameroff. One could argue that since the periodicity as winding number is a topological characteristics, the correct identification should give all winding numbers or at least those which are Fibonacci numbers in case A-type microtubules.

What about B-type microtubules?

- 1. For B-type microtubules one obtains 4 pathways, one of them parallel to the microtubule and the remaining three with periodicity 7. Only the gaps 2, 3, 4 are allowed by the "don't touch" rule. 2 and 3 do not decompose and 4 decomposes to (4, 2) so that 2 and 4 can co-exist.
- 2. For the axial pathway X there is no restriction to the values of n_{gap} unless one just assumes $n_{gap} = 2$ as in the illustration of slides. It is argued that together A and B-type pathways cover the entire series. I failed to understand what this means: in any case, the primary gap number $n_{gap} = 12$ is missing and I find difficult to understand what complementarity could mean.
- 3. The 3 pathways 2, 3, 4 are parallel and cannot intersect each other but they can intersect the axial pathways called X so that braiding is possible. For X type pathways conduction would take place along sequence of $\alpha \beta$ pairs.
- 4. For A-option one obtains only periodicity 13 and for B option periodicity 7 for primary gaps 2, 3, 4 and periodicity 1 for the line parallel to microtubule with periodicity 1.

Bandyopahyay emphasizes that A-type pathways are ideal for TQC whereas B-type pathways are ideal for communications. I did not understand the argument. Certainly this requires that a phase transition from B to A can take place.

The transitions reported to occur as the microtubule is excited at certain resonance frequencies, would in this picture correspond to transitions between different groups rather than excitation of single pathway. The number of resonance frequencies is reported to be 8. If there are n pathways

all possible transitions would give n(n+1)/2 resonance frequencies: this number cannot be equal to 8 unless some frequencies are degenerate. It would seem that more plausible interpretation is in terms of excitation of a physical state assignable to given pathway or group of its parallel translates rather than between groups of them.

Microtubules from TGD point of view

In TGD framework microtubules are especially interesting from the point of view of TQC - both for 1- and 2-braids and MTs might represent an evolutionary step in which 1-braid TQCs were extended to 2-braid TQCs.

1. What does one mean with TQC?

I ended up with my own proposal about TGD Universe as topological quantum computer (TQC) around 2002 [K7] with inspiration coming from New Scientist article [C4] - at the same time Hameroff has proposed the idea about conducting pathways as braids. By looking at old blog articles I learned that I have developed the vision about DNA as TQC during 2007 [K6, K138].

The proposal is that the braiding of magnetic flux tubes associated with the magnetic bodies of biomolecules - and probably also much larger structures - makes possible TQC like activities basic aspect of living systems. For instance, braids connecting DNA and nuclear and cellular membranes could make possible automatic construction of memories as space-like braidings of magnetic flux tubes induced by time like braiding generated by the liquid flow around cell and nuclear membrane [K6]. Also microtubules could be connected to axons by flux tubes and similar mechanism could be at work. A universal representation of memories could be in question and couple microtubules directly to the neural activities.

It is essential that the second of each braid is free to move so that temporal braiding patterns are generated and induce spatial braiding patterns (dance metaphor helps to visualize this [K6]). Second essential point is that the qubits reside at the ends of braid strands. This is why the statement of Penrose and Hameroff that conduction pathway defines a qubit in some manner - say in terms of current direction - does not make sense in standard TQC paradigm. In the following I shall propose that the statement can be made to make sense if one considers generalization of TQC involving 2-braids instead of 1-braids so that 2-D objects get "knotted" instead of 1-D objects [K66].

The braiding induced by say 2-D flow of lipids would still be passive generation of memories but one could consider also genuine quantum computation like activities in which the braiding defining the TQC program is constructed in a controlled manner. For instance, one could associate to microtubular surface highly regular "pre-braidings" involving crossings of magnetic flux tubes for which basic braiding operation (swap) between neighboring braid strands could be controlled by the tubulin molecule associated with the crossing. Swap could be determined by the tubulin conformation in the crossing defining a classical bit so that classical computer program expressible as cylindrical surface decorated with bits would code TQC program. In this manner coupling of the events at cell membrane to microtubular quantum cognition would be achieved.

What one exactly means with topological quantum computation (TQC) is not at all obvious and one can consider several variants of it in TGD framework.

1. Zero energy ontology (ZEO) leads to the notion of unitary U-matrix and orthonormal basis of M-matrices which are "square roots" of density matrices expressible as products of hermitian matrix and unitary S-matrix depending on the size scale n of CD in very simple manner: $S(n) = S^n$, where S is the S-matrix for the minimal sized CD.

M-matrices define time-like entanglement coefficients between the positive and negative energy states at the opposite boundaries of causal diamond (CD). For braid strands along light-like 3-surfaces defining string ends one obtains entanglement between fermions at the ends of strands. Since the entanglement matrix is unitary it defines density matrix which is sum over projection operator acting as identity matrices and state function reduction yields a negentropically entangled state carrying information. One can pose additional conditions on space-time like negentropic entanglement (NE) (see Fig. http://tgdtheory.fi/appfigures/cat.jpg or Fig. ?? in the appendix of this book) and ends up with a highly

unique form of entanglement coefficients from the condition that any splitting of the system to two parts defines negentropic entanglement [K80].

Under rather natural assumptions S-matrix reduces to a unitary representation of scaling of causal diamond (CD) [K85]. 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 turns out possible to construct a general representation for the U-matrix reducing its construction to that of S-matrix.

- 2. In absence of degeneracy giving rise to negentropic entanglement one would have ordinary entanglement and ordinary quantum measurement theory applies. The outcome of TQC would be statistically determined from state function reductions for large enough number of sub-CDs of given CD. It would be coded by quantum classical correspondence (QCC) to the parameters characterizing classical fields inside CD (frequencies, wave numbers, ...). EEG patterns would be one particular representation of this kind.
- 3. The sequence of state function reductions defining sub-self as mental image would correspond to the reading of Akashic records as kind of TQC. TQC would represent "Akashic records" and by NMP Universe would be building increasing library of Akashic records. This might provide a general mechanism of term memory.
- 4. Also a generalization of ordinary 1-braid TQC to 2-braid TQC is suggestive. 1-D braid strands define braiding of orbits of point like particles in 3-D space space-time say light-like 3-surface. In TGD framework the 1-D braid strands correspond to the boundaries of 2-D string world sheets and the evolution of string world sheets corresponds to 2-braid in space-time. One obtains a generalization of 1-braid TQC to 2-braid TQC in which knotting occurs for 2-D string world sheets of 4-D space-time rather than 1-D strings of 3-D space.

Qubits at the ends of time-like braid strand are replaced with quantum states at space-like braid strands defining ends of string world sheet and TQC corresponds to a time evolution in which the 2-knotting of braid strands changes. The first basic operation is what Alexander the Great did for the knot - the breaking of 1-knot temporarily. What happens is following: if braid strand A goes over B before the moment of breaking, it goes below B after it. This is however not the only possible operation: also reconnection - basic operation for magnetic flux tubes - can take place: the braids strands AB and CD are replaced with AD and CB. These operations define standard vertices in closed string model. The sequence of these operations defines 2-braiding and one can assign to it a generalization of 1-braid TQC to 2-braid TQC. 2-braid TQC is not possible in super string models since strings are embedding in space-time having dimension higher than D = 4.

The quantum states of braids strand would define qudits. In TGD qupits representable as superposition of p^N states, p prime, are of special interest in TGD framework.

2. Could MTs lead from 1-braid TQCs to 2-braid TQCs?

What can one say about the situation concerning microtubules in TGD framework? Since I am not a professional biologist, I can imagine rather freely.

Consider first TQC in the standard sense, that is for 1-braids.

1. The obvious question concerns the nature of the braid strands (conduction pathways in the terminology of Penrose and Hameroff) and here standard physics cannot provide much insight. A natural TGD based identification would be in terms of magnetic flux tubes carrying dark electrons or even better, their Cooper pairs forming currents running along the micro-tubule. This would predict that microtubules act as super-conductor like systems. The basic aspect of this kind of system is resistance which does not depend on the length of the wire since the resistance is determined by what happens at the ends of the wire where electron current enters or leaves the wire - now flux tube. For ordinary superconductors the resistance involves term which does not depend on temperature. Also now one might expect that the resistance has similar behavior.

The states of Bose-Einstein condensate at the braid strand cannot defined the qubits in ordinary 1-braid TQC for which the states reside at the ends of braid matter. The flux tubes should have ends - at least effectively. The ends should carry quantum numbers defining the qubits. The effective end would correspond to wormhole throat of a wormhole contact at which the magnetic flux flows to another space-time sheet. Quite generally, the flux tubes would be closed structures: for instance, elementary particles correspond to two-sheeted flux tubes having two wormhole contacts as "ends".

- 2. Maybe the tubulin at the crossing point could induce swap or not depending on its state. Tubulin dimers possess two different configurations and the original proposal of Hameroff was that these configurations correspond to two values of bit. The bit represented as a tubulin conformation would tell whether the left-handed strand runs above or below the righthanded strand at the crossing. The braiding would have representation as a 2-dimensional cylinder with points representing classical bits determining the TQC program. Classical computing and quantum computing would couple together. If tubulin conformations could form quantum superpositions, one would have "quantum-quantum-computation". According to [J52], the process inducing the change of tubulin conformation is chemical irreversible process so that this option does not seem to be possible.
- 3. The swap at the crossing point for certain value of time would be determined by the state of the tubulin at the crossing at particular moment. At each moment the braiding pattern for braids connecting microtubule ends would determine the TQC program in terms of entanglement matrices proportional to unitary matrices. What is important is that unitary matrix between the states at the ends of braid gives rise to NE with entanglement probabilities forming a matrix proportional to unit matrix. The NE alone could be in principle source of conscious information obtained during sequence of state function reductions at a fixed boundary of CD defining self. These states or selves would define what I have called "Akashic records" responsible for memory storage as quantum invariants.

What is new that a generalization of TQC based on 2-braids defined by string world sheets can be imagined. The idealization of time evolutions of magnetic flux tubes can be idealized as string world sheets so that magnetic flux tubes would become key players also in 2-braid TQC. The transition from DNA as TQC to MT as TQC could correspond to the replacement of 1-braids with 2-braids. The quantum states of 2-braid TQC would corresponding unhalting 1-braid TQCs. This would represent a step leading to a higher abstraction level and could play a fundamental role in evolution in accordance with the role of emergence of microtubules in ontogeny.

1. The states of braid strands could define qubits for TQC based on 2-braids defined by string world sheets assignable to time evolutions of flux tubes idealized as strings.

The spin direction of cyclotron Bose-Einstein condensate defines one candidate for qubit. The direction of DC current along braid strand could also define qubit. If the system is ideal Josephson junction then a constant voltage should however gives rise to an oscillating current. The presence of resistances at the ends of the flux tubes is expected to give rise to the standard form of Ohm's law in average sense.

- 2. The hysteresis curve for the micro tubular current I as function of voltage V between the ends of microtubule is reported to be square [J55] so that the phase transition changing the current direction could be quantum phase transition at criticality and make possible qubits as superpositions of both current directions near criticality for the current flip. TQC would halt when the voltage is changed so that it is not in the critical region anymore.
- 3. For magnetic flux tubes the vertex changing swap for 1-braid corresponds to reconnection, which would therefore find a new application in TGD inspired biology. I have earlier proposed that the ATP-ADP transformation generates reconnection but failed to realize that the interpretation could be in terms of 2-braid TQC. Energy metabolism as a continual occurrence ADP→ATP and its reversal could be also a direct signature of 2-braid TQC. The spatio-temporal pattern of ADP↔ ATP transformations would reveal the TQC program code.

4. The change of the conformation of tubulin molecule would induce a swap. The reconnection of flux tubes -perhaps also induced by a change in the conformation of tubulin molecule - is also possible. The TQC program for 2-braids would be coded by the temporal history of changes of tubulin conformations represented in terms of bits. Chemistry would be used to write TQC programs. 2-braid TQC could be seen as sequence of 1-braid TQCs, which need not halt.

Admittedly, the model involves several new physics elements, which skeptic with Occam's razor could use to debunk the approach: dark matter hierarchy represented as hierarchy of effective Planck constants, the motion of magnetic body implied by the TGD based geometrization of classical fields and new view about space-time, and the notion of NE and Negentropy Maximization Principle [K80] defining the variational principle of TGD inspired theory of consciousness. These new elements are not however ad hoc assumptions but basic pillars of quantum TGD.

3. Identification of conduction pathways

Consider next the detailed identification of the conduction pathways assumed to correspond to a grid formed by flux tubes.

The interpretation of Bandyopadhyay has some problematic aspects. The proposed parallel strands do not intersect and cannot therefore define braid. The transitions to which the resonance frequencies are assigned, are not identified. No comment is represented concerning the problem that A-type microtubules have not been observed experimentally. From these problematic aspects it takes some time to end up with TGD based vision about the situation.

1. In TGD framework it is natural to regard the pathways of A-type microtubules as obtained by 2π twist for the "upper" end of B-type pathways which are of type X and possess the primary gap numbers allowed for A-type groups: recall that this gives 4 groups of four primary gaps. The pathways obtained from the transversal pathways of B-type microtubules by 2π twist define an excellent candidate for the complementary pathways needed to obtain crossings and braiding.

What looks like a problem is that the twist for the 3 groups of 7-periodic pathways would produce two 7-periodic pathways per 13-unit, which corresponds to 14 rather than 13 tubulins rather per basic unit. The only explanation is that the discontinuity disappears and implies that there one has 13 tubulins per single structural unit of Q-type tubule.

- 2. If one excludes the decomposable pathways with $n_{gap} = 4$, the twists of 2 and 3 groups would define transverse pathways for A-type microtubules. Altogether 8 different coordinate grids formed by the pathways now magnetic flux tubes would be obtained. The 8 resonance frequencies would correspond to the phase transitions $A \leftrightarrow B$ induced by $\pm 2\pi$ twist for the "upper" end of the basic unit.
- 3. In TGD framework the most natural explanation for why A type tubules are ideal for TQC is that they correspond to a large value of h_{eff} , and the phase transition increases the value of h_{eff} and makes superconductivity and TQC possible for A type tubules. Unitary S-matrix characterizing TQC defines entanglement probabilities which are identical so that NE is in question. NE is very closely related to large value of $h_{eff}/b = n$: n corresponds to the number of entangled states in the simplest situation.
- 4. One can estimate the value of h_{eff} if the AC radiation inducing the phase transition corresponds to dark photons with energy which is above thermal energy. For the energy $E \simeq 2$ eV of visible photons this would give for 8 MHz frequency $n = h_{eff}/h \simeq 6 \times 10^7$. For IR frequencies above thermal threshold which corresponds to the energy $E \simeq .05eV$ assignable to resting potential, one would have $n = h_{eff}/h = 10^5 10^6$.

Corresponding p-adic length scales giving estimates for the length scales of flux tubes would scale like $n^{1/2}$. For B-type microtubules the p-adic length scale would be naturally 5 × 4 nm corresponding to 5-periodicity and 4 nm length diameter for single tubulin. For A-type microtubules corresponding scale would be by factor 10^3 longer for IR frequencies: upper bound would give 20 μ m. The length of microtubules obtained in experiments ranges from 2μ to 25 μ m so that the estimate seems to make sense.

4. Could frequency hierarchy correspond to a p-adic hierarchy of magnetic flux tubes?

The hierarchy of frequency scales kHz, MHz, and GHz could correspond to cyclotron frequencies for electron and perhaps also proton. In particular, the crucial role of water in making conductivity possible suggests that protonic cyclotron B-E condensate is important in the water core of MT at least but possibly also in longer length scales.

- 1. TGD allows magnetic monopole fluxes for flux tubes: in this case the cross section of the flux tube would be closed 2-D surface (sphere) rather than disk, and no current rotating around the tube would be needed to create the magnetic flux. This kind of flux tubes could explain the presence of magnetic fields in cosmic scales: in Maxwellian cosmology they are impossible in early cosmology because the needed currents are to possible. This kind of fluxes might be associated with super-conductors and even permanent magnets. The unit of magnetic flux tube the flux is $\Phi = \int eBdS$ is h/2 for a disk cross section. For spherical cross section of monopole flux tube the flux is $\Phi = \oint eBdS$ and unit is 2h that is 4 times larger. This could serve as a test for whether one has monopole flux or standard flux.
- 2. I have proposed that constant endogenous magnetic field $B_{end} = .2$ Gauss= $.2 \times 10^{-4}$ Tesla could explain the effects of ELF radiation to vertebrate brain as resulting from cyclotron transitions of large h_{eff} B-E condensate. The recently updated model replaces cyclotron transitions with phase transitions scaling the value of p-adic prime and thus the value of the magnetic field. The model yields essentially the same predictions as the earlier model. The phase transition scales down the radius of the flux tube characterized by p-adic length scale $L(k) \simeq 2^{(k-151)/2} \times L(151), L(151) \simeq 10$ nm by a power of two: the increase in cyclotron energy due to the reduction of flux tube radius is in good approximation $ne(B_f B_i)/m = neB_f(1-2^k) \simeq neB_f$, where B_f is the field strength for the compressed magnetic flux tube.
- 3. For electron in endogenous magnetic field of 2 Gauss cyclotron frequency is $f_e \simeq .5$ MHz: for proton one has $f_p \simeq 300$ Hz (note that the ratio of cyclotron frequencies of electron and proton is given by the mass ratio $m_p/me \simeq 1843 \sim 2^{11}$). The reported resonance frequency is $f \simeq 8$ MHz, which is 2^4 times higher than f_e . This suggests that the irradiation induces p-adic phase transition of flux tubes contracting them by a factor 1/2 and increasing field strength by a factor 4. This would mean that the p-adic length scale is reduced from L(k)to L(k-4). The possibility of this interpretation yields support for the p-adic length scale hypothesis.
- 4. Purely number theoretic considerations predict that in biologically interesting length scale range ranging from 10 nm to 2.5 μ m there are four p-adic length scales which correspond to Gaussian Mersenne primes $M_{G,n} = (1+i)^n - 1$, n = 151, 157, 163, 167. One could speak of a number theoretic miracle. It is easy to see that the transition induced by 8 MHz radiation could correspond to the transition $k = 167 \rightarrow 163$ for electron. This gives strong support for the fundamental role of these Mersenne scales.

First, B_{end} corresponds to magnetic length of $L_B = \sqrt{\hbar/eB} = 5.7 \ \mu\text{m}$ not far from the p-adic length scale L(169) is $L(169) \simeq 5.1 \ \mu\text{m}$. L_B would give flux quantum h/2. The problem is that this scale is by a factor 2 longer than the Mersenne scale L(167). Situation changes if the flux is monopole flux for flux tube with spherical rather than disk-like cross section. By previous argument the flux quantization would be obtained for a sphere with radius given by the p-adic length scale L(167). One would obtain Mersenne scale and the transition $L(k) \rightarrow L(k-4)$ would correspond to $k = 167 \rightarrow k = 163$. Proton cyclotron frequency would be scaled up in this transition to 4.8 kHz and it would be natural to identify frequencies in kHz frequencies as harmonics of f_p .

5. The scaling $k \to k-11$ would transform $f_e = .5$ MHz to $f_e = 1$ GHz. The p-adic scale would become k = 156. k = 157 would have been more attractive outcome. $L(156) \simeq 57.6$ nm looks too large to be radius for a magnetic flux tube assignable to the MT strand of thickness of order 4 nm. I would more naturally correspond to the length scale defined by a strand of 13 tubulins.

- 6. Microtubule strand corresponds to length scale 4 nm which suggests that p-adic length scale L(149) assignable to lipid layer of cell membrane characterizes the flux tubes defining the coordinate grid at MT surface. GHz frequency is assigned with the order water in the interior of MT $L(145) \simeq 1.25$ nm seems to be a good candidate for the corresponding p-adic length scale. $f_p = 1.35$ GHz frequency is obtained if flux the transition is $k = 167 \rightarrow 145$.
- 7. An attractive possibility is that the flux tubes in the interior of MT contain dark proton sequences defining the dark nuclei with single dark proton with large value of Planck constant h_{eff} with size scale of single DNA codon. The amazing prediction of the model of dark nucleon is that the counterparts for the DNA, RNA, amino-acids and even tRNA are obtained and vertebrate genetic code can be realized as a natural correspondence between these states [K62, L3]. One can imagine the possibility that the dark genetic codes inside MT and connected by radial magnetic flux tubes to the codons at the braid strands at the surface of MT.

5. About B-type lattice

Some TGD- and computer science inspired comments on B-type lattice are in order.

- 1. B-type lattice is discontinuous along vertical line. There is a horizontal pair of α and β tubulin monomers at discontinuity and here α (β) tubulins have 3 instead of 2 nearest neighbour β (α) tubulins. Could the possible flux tubes connecting microtubule to the axonal membrane and making possible to receive sensory input begin here? The flux tube pair parallel to this line brings in mind DNA double strand. The α - or β -sequences with vertical 5-periodicity would be discontinuous after full turn: the shift in vertical direction would be 5 tubulin units but single turn of the helical path would correspond to a vertical shift of 4 tubulin units only.
- 2. The discontinuity suggests that the tubulin consists of pieces of 13-units maybe defining a sequences of 13 binary digits as code words kind of bytes in turn defining the classical computer code giving rise to TQC code.
- 3. A second interesting aspect is the 7-periodicity of transversal pathways in axial direction. One of the TGD inspired models for genetic code [K61] interprets 64 genetic codons as a subset of 127 element space consisting of $2^7 1$ elements identified as a subset set of mutually consistent logical statements of 7-bit algebra so that the negation of the statement cannot belong to the set.

Statements would be analogous to axioms of mathematical system being identically true. One statement is non-realizable: in case of set theoretic realization it would be naturally empty set. If statements are realized as spin excitations of ferromagnet then absence of spin excitations would correspond to the non-realizable statement. One could also argue that only communicable statements are possible. Communication of the state could be defined as radiation generated by the transition from the ground state to a multiply excited state. If there is no change (ground state goes to ground state), the statement is not communicable. Could 7-bit sequences be restricted by the condition that they represent identically true statements? This condition would make possible error correction mechanism analogous to parity bit.

6. Could DNA sequences code for TQC programs?

One also ends up with a rather crazy idea about possible interpretation of genetic code.

- 1. If one piles up 2-D TQC: s one obtains 3-D 1-braid TQC. In crossings one must have 3 bits to specify whether to swap or not since there are three planes for TQC and 3 pairs of crossing strands (12, 13, 23).
- 2. For 2-braid TQC one obtains 6 bits at each crossing of 3-D grid. The first bit tells whether reconnection occurs and second tells which of the resulting crossing strands goes over the other. One can imagine even a concrete realization. DNA strand which is a coil with radius of 10 nm could be accompanied by a flux tube and there would be for each codon to flux tubes crossing this flux tubes so that 6 bits would be needed to characterized the 2-braid

locally. DNA as TQC model suggests that second flux tube connects DNA codons to a helical flux tube at lipid layer of nuclear or cell membrane. Second strand could connect it to similar tube at cell membrane.

3. Just for fun one can imagine also a second, even more science fictive realization. If one further piles 3D TQC: s in 4-D one obtains 4-D one making sense in zero energy ontology because failure of strict non-determinism is basic element of TGD. Single crossing would in 4-D would involve crossings of four lines in orthogonal dimensions. TGD predicts also space-time regions with Euclidian signature in all scales (lines of generalised Feynman diagrams). I have proposed that any system corresponds to an Euclidian space-time sheet having its size and shape and behaving like quantum system. In these regions the fourth piling might really make sense!

This would make 6 crossing pairs corresponding to 6 planes in which particular TQC takes place - for which one must tell whether to swap or not (12, 13, 14, 23, 24, 34). This makes 6 bits. DNA codons correspond to 6 bits! Could codons define crossing points of magnetic flux tubes arriving from 4 coordinate directions- perhaps at Euclidian space-time sheets? Could the planes correspond to 3 components of magnetic field and 3 components electric field. Magnetic flux tubes and electric flux tubes in 3 directions? In Euclidian regions magnetic and electric do not differ intrinsically. It is however difficult to concretize this proposal.

In the following I try to understand the observations reported by Anirban Bandyopadhyay (http://tinyurl.com/ze366ny) in TGD framework.

The observations of the group of Anirban Bandyopadhyay from TGD point of view

The observations of Anirban Bandyopadhyay are briefly summarized by Massimo Pregnolato. At this stage one can of course several models for the findings and in the following one option is selected.

- 1. The most plausible model is based on the notion of coordinate grid formed by longitudinal and transversal magnetic flux tubes whose crossing points are the points at which swap occurs or does not occur depending on the state of tubulin dimer. The grids associated with A and B tubules are obtained by a 2π twist for the upper end of the tubulin.
- 2. There is a large number of options for grids and they are identified on basis of the experimental findings. Transversal coordinate lines would correspond to the 7-periodic parallel lines with either gap 2 or 3 (gap 4 lines decompose to gap 4 and gap 2 lines) and longitudinal coordinate lines to one of 4 line groups involving four gaps so that 8 coordinate grids are obtained and related by a 2π twist for A and B tubules respectively. Gaps could characterize measurement resolution.
- 3. For A-type microtubule one can consider also Fibonacci grids constructed from helical curves and their mirror images with periodicities 3, 5, 8, 13 and arbitrary gaps but it is difficult to interpret the resonance frequencies and understand their number for this option.

1. Fröhlich B-E condensation or something else?

Excitation at the resonance frequencies cause microtubules to assemble extremely rapidly. This is proposed to be due to Fröhlich condensation. The resonance frequency of AC stimulation leading to a rapid generation of microtubules in the length scale range $[.2 - 22.5] \mu m$ is around 8 MHz. There is correlation between resonance frequencies and lengths of microtubules and qubit sets that are possible.

Comment: The identification as formation of Fröhlich B-E condensate can be criticized. The frequency at which this would take place was predicted by Fröhlich to be around GHz rather than in MHz range.

In TGD framework AC stimulation could generate flux tube grid or activate existing magnetic flux tube grid forming a braid like structure serving as a template for the formation of microtubule around it. If the formation of grid corresponds to quantum criticality, the resonance frequencies could also generate phase transitions between A and B type states of the microtubuli. AC signal could also generate contacts to these flux tubes making possible supra currents. The formation of microtubules is known to proceed by the formation of vertical nucleotide polymers which are then glued together horizontally: flux tube could serve as a template for the formation of the nucleotide polymer. The magnetic fields at flux tubes can be accompanied by helical electric fields (in this case both magnetic and electric fields are helical) and these fields could be responsible for the polarization of microtubule and induce the growth of microtubules in such a way that the polarized alpha-beta tubulin always attaches in the same manner to the growing polymer. Fröhlich condensation would be a consequence of generation of flux tube coordinate grids defining microtubule skeleton- growth of the magnetic body would precede that of biological body.

The length of the tubule increases with resonance frequency which suggests that single tubulin dimer is added to the polymer during each cycle. MHz range and formation time around few seconds. This would mean something like 10^6 giving MT with length of order 10^{-4} meters. The order of magnitude is correct.

2. 8 resonance frequencies in AC stimulation and 8 distinct interference patterns

Microtubules are reported to have 8 resonance peaks for AC stimulation (kilohertz to 10 megahertz), which appear to correlate with various helical conductance pathways around the geometric microtubule lattice. The explanation is proposed in terms of current pathways which are identified topological qubits.

Comment: To me this terminology looks strange and confusing. Why not to speak about braid strands or specify what topological qubit means if one is speaking about TQC? I am unable to understand why groups of parallel pathways are considered as topological qubits (TQs). The idea about parallel translates might however make sense.

As already explained, the notion of coordinate grid in the sense discussed is consistent with the findings. The resonance frequencies could correspond to phase transitions changing A-type coordinate grids to B-type or vice versa. Coordinate grid would define the basic architecture of TQC.

The second claim is that there are altogether eight distinct quantum interference patterns from a single microtubule, each correlating with one of the 8 resonance frequencies and pathways. According to the interpretation discussed in the talk 4 sets of four pathways representing quantum TQ each can exist simultaneously for type A microtubules claimed to be ideal for quantum computation. Lattices of type B exhibit 4 different pathways and are claimed to be ideal for communications. The lattices A and B are complementary in the sense that together they allow all possible pathways (this is not quite true: $n_{gap} = 12$ is lacking). The set of possible pathways depends on the length of MT.

Comment: Also this would conform with the TGD inspired model in which one has 8 coordinate grids for tubules of B and their deformations by twist to A type tubules. The 8 interference patterns would correspond to different coordinate grids. What coordinate grids are physically allowed coordinate grids are depends the length of the microtubule.

3. Observations about conductivity

There are also several observations about conductivity suggesting quantum coherence.

1. In assembled microtubules AC excitation at the resonant frequencies causes electronic conductance to become lossless, or "ballistic", essentially quantum conductance, presumably along these helical quantum channels. Resonance in the range of kilohertz demonstrates microtubule de-coherence times of at least 0.1 millisecond. Does this mean that AC signals at resonance frequencies are able to create these channels or groups of them?

Or does this mean, that the resonance signal transforms the microtubule to A (or B) type lattice which is highly conducting or even super-conducting (via magnetic flux tubes). The claim that A type lattice does not exist in vivo reduces to the statement that it does not exist stably in vivo. The AC signal at resonance frequency induces the twist taking lattice B into lattice A in which TQC is possible.

2. There are three frequency scales corresponding to kHz Hz, MHz and GHz ranges. The natural identification for these rather low frequency scales is in terms of cyclotron frequencies of dark electrons and possibly also various ions at magnetic flux tubes. The simplest identification

would be in terms of three ranges for the strengths of magnetic field. I have proposed that.2 Gauss magnetic field define endogenous magnetic field explaining the effects of ELF em radiation on brain in terms of cyclotron transitions of biologically important ions, in particular Calcium ions for which cyclotron frequency would be 15 Hz (later an alternative explanation making essentially the same predictions has emerged). For electron the cyclotron frequency would.5 MHz so that for 16 times strong field would correspond to cyclotron frequency of 8 MHz appearing as resonance frequency. GHz frequency would require a magnetic field of 0.04 Tesla.

3. It is stated that the system cannot be classified as insulator, semiconductor, or conductor. The reason would be that the two bands involved do not overlap as in conductors, are not completely separate with large gap as in insulators, nor separate with a small gap. Instead the bands touch each other in pointwise manner.

Comment: Stimulus with the resonance frequency could regenerate the flux tubes or bridges to the flux tubes allowing the transfer of electrons to them. The ballistic resistance temperature independent resistance would be due to a very long free path or due to super-conductivity at the magnetic flux tubes - the latter is the TGD inspired hypothesis. This kind of behavior could result if the electrons can leak to the flux tube only if they have same momentum as the Cooper Bose-Einstein condensate at the flux tube. Resonance condition would mean that the magnitude of the wave vector of electron is quantized in magnitude: this would also support the proposed interpretation.

4. It is claimed that conductance does not depend on microtubule length, is temperature independent, and has discrete values. Also ohmic dissipation is claimed to be negligible.

Comment: The interpretation could be in terms of superconducting current pathways defined by magnetic flux tubes looks natural as already found.

The observation that water is necessary for MT conductivity [J54] suggests that the presence of water is essential for large h_{eff} . One of the many possibilities is that the flux tubes (which are closed) return through the interior of MT containing the ordered water. Also dark variants of genes realized as dark proton sequences dark nuclei could be involved.

4. Ferroelectric hysteresis

What is interpreted as ferroelectric hysteresis is claimed to demonstrate memory capacity in microtubules [J55]. Current viz. voltage over the microtubule exhibits square hysteresis. Suddenly all-in one jump changing the direction of current at critical voltage. This is analog of ferromagnetic or ferroelectric behavior but in completely quantal manner.

One can ask whether the quantum superpositions of two current directions might represent qubit. If so, the information processing capacity of microtubule would be rather modest unless one consideres seriously 2-braid TQC. (recall however that in neuroscience single neuron is assumed to represent bit).

It is not at all obvious that ferroelectric hysteresis is in question and TGD suggests different interpretation for the hysteresis curve. The current as function of voltage could reflect quantum coherent current in Bose-Einstein condensate of electronic Cooper pairs with all Cooper pairs having the same momentum. Macroscopic quantum coherence would make the state stable against perturbations defined by the external voltage and only when the voltage exceeds critical magnitude the state would change its momentum to opposite values instantaneously. If the interpretation as cyclotron BE-condensate is correct one would have Cooper pairs with spin 1 in same state and effectively only single particle representing memory.

The assumption of Bose-Einstein condensate might be unnecessary strong: negentropic entanglement might be enough. Dark electrons are negentropically entangled and the entanglement stores potentially conscious information. The degeneracy of the ground state essential for achieving stable enough entanglement also in standard approach to TQC. The NE would not be in spin degrees of freedom but in those labeling sheets of the covering of M^4 and CP_2 defined by the spacetime sheet of electron. Anti-symmetry in these exotic degrees of freedom would make electrons bosons if seen from the perspective of standard physics and allow them to effectively B-E condense to the same state with respect to standard quantum numbers. Note that this proposal resembles somewhat the proposal of Hameroff and Penrose for topological qubits in terms of parallel current pathways with same gap. In this case the NE could perhaps stabilize the state in the sense that NMP [K80] would not allow the quantum jump leading to opposite direction of electron current to take place.

5. Dynamical instability of MTs

MTs are dynamic instable and the length of MT changes in jumps. The conjecture is that some kind of language is involved. On basis of few second time scales one can wonder whether the correspondence with language production could be rather direct. Could regions of type A contain the information communicated in speech, say the information needed to form words or sentences? If microtubules of type B are indeed responsible for communications, one can ask whether $A \rightarrow B$ phase transitions generate the signal in turn inducing the nerve pulse patterns correlating with internal speech. The connection with language could be realized also at gene level [K61].

I have proposed that microtubule acts as quantum antenna emitting radiation with frequencies $f_n = nc/L$, where L is the length of MT. The variation of the length of microtubule would predict frequency modulation of the radiation coding for potentially conscious information. The model for nerve pulse and EEG makes similar prediction [K103, K48]. Josephson frequency for cell membrane as Josephson junction is proportional to membrane voltage and the variations of membrane voltages due to oscillations and nerve pulse activity are coded to EEG via frequency modulation. Even ordinary speech involves frequency modulation as is clear by listening recorded speech with abnormally slow speed. If microtubules talk, the most natural language would be based on frequency modulation.

The system seems to be critical, maybe it is quantum critical in TGD sense. At quantum criticality the dynamics involves a large number of length scales. In TGD framework quantum criticality would mean that the hierarchy of Planck constants is involved such that given length scales is proportional to the effective value of Planck constant. Maybe different lengths for flux tubes correspond to values of effective Planck constant $h_{eff} = nh$.

Conclusion

The important conclusion suggested by the experiments is that microtubules - in particular, brain microtubules - are macroscopic quantum systems. Already this would be enormously important conclusion. To my personal opinion, the interpretation in the talk is not convincing at the level of details and TGD inspired modification of the proposal in terms of flux tube coordinate grids making possible TQC architectures with tubulin dimers defining bits defining in turn TQC program looks more plausible to me. A natural generalization of of 1-braid TQC to 2-braid TQC is also highly suggestive in TGD framework and could be seen as evolutionary step assignable to the emergence of microtubules. The interpretation based in Fibonacci conduction paths fails to predict correctly the number of resonances. An attractive interpretation for the resonance frequencies is in terms of phase transitions between A and B type lattices. If A type lattices can be generated only in h_{eff} increasing phase transitions induced by AC stimulus at resonance frequencies, one could understand their experimental absence and why super-conductivity like state is generated.

8.13.7 Morphogenesis, Morphostasis, And Learning In TGD Framework

Michael Levin and his collaborators have been working with fascinating topics including fundamentals of long term memory and morphogenesis and morphostasis [I104, I105, I129]. I am grateful for Lian Sidorov for bringing these articles to my attention.

There are two articles about morphogenesis and morphostasis. The first article [I104] (http://tinyurl.com/y9le7wme) seems to be directed to general audience and has the title "The wisdom of the body: future techniques and approaches to morphogenetic fields in regenerative medicine, developmental biology and cancer". Second article [I105] titled "Morphogenetic fields in embryogenesis, regeneration, and cancer: Non-local control of complex patterning" (http://tinyurl.com/ydfq28cb) is more technical. The basic notion is morphogenetic field, an old notion, which has not captured the attention of main stream biologists who have worked mainly with the attempt to reduce biology to genetic code. Sheldrake's work [L19] with the notion has drawn special attention but there are many other workers in the field.

The third article [I129] by Levin and Shomrat has title "An Automated Training Paradigm Reveals Long-term Memory in Planaria and Its Persistence Through Head Regeneration" (http: //tinyurl.com/ycsfs6zc) challenging the belief that brain is the only seat of memories.

According to Levin, the basic challenge of morphogenetics and morphostasis is to understand how the shape of the organism is generated and how it is preserved [I105]. The standard local approach based on belief on genetic determinism does not allow answer these questions satisfactorily. There is paradigm based on self-organization in which the local dynamics of cells leads to large scale structures as self-organization patterns. The game of life is an elegant example about how simple cellular automaton can lead to surprisingly complex behaviors: actually the game of life is universal Turing computer. The problem of this approach is that it is very difficult to deduce the local rules governing the behavior of basic units (whatever they are) in practice- especially so if they are also dynamical.

Second approach could be seen as computational with basic idea being that the process is guided by a template of the target state. Morphogenetic fields would define this template. The assumption about final goal can be argued to be too strong: much weaker principle defining a local direction of dynamics and leading automatically to the final state as something analogous to free energy minimum in thermodynamics might be enough. Unfortunately, second law is the only principle that standard physics can offer.

These problems are very relevant also for medicine [I104] since morphogenesis, morphostasis, and cancer all involve actively replicating cells: the difference is that in cancer the control and long scale coordination of the process fails and it becomes purely local process. Levin refers to cancer as geometric disease and it seems that this correction contains seed of truth.

These topics are also interesting from the point of view of TGD inspired quantum biology and consciousness. There are several new notions to be tested.

- 1. The new view about time and quantum implied by zero energy ontology (ZEO). In TGD framework the notion of preferred extremals as 4-D space-time sheet analogous to Bohr orbit, for which strict determinism of dynamics fails, replaces 3-space as basic unit. One can understand self-organizaton process in 4-D sense rather than 3-D sense: geometric time evolution would be replaced by subjective time evolution by quantum jumps. This could resolve the basic difficulty of the ordinary self-organization paradigm. Geometro-temporal pattern approaches to asymptotic quatum jump by quantum jump one rather than 3-D pattern.
- 2. The new view about information relying on the notion of negentropic entanglement and Negentropy Maximization Principle (NMP). NMP could be the principle guaranteeing local positive goal making healing and evolution basic processes of Nature. In particular, the development of shape and shape preservation of organisms could involve NMP in essential manner. Also the approach of WCW spinor field to the maximum of vacuum functional (or equivalently that of Kähler function) gives a goal for the dynamics after the perturbation of the organism causing "trauma". If Kähler function is classical space-time correlate for entanglement negentropy, these two views are equivalent.
- 3. The notion of magnetic body (MB) carrying dark matter as phases with large value h_{eff} of Planck constant making living matter a macroscopic quantum system and providing a tool kit of quantum mechanisms (phase transitions changing the value of h_{eff} and thus the length of flux tube, reconnections changing the topology of magnetic Indra's net, and 1-braiding of flux tubes 3-space and 2-braiding of their orbits in 4-D space-time). Magnetic body defining a kind of coordinate grid is a good candidate for the TGD counterpart of morphogenetic field serving as a template for the developing organism. It would also give rise to topological quantum computation (TQC) type activities.

The coordinate grid formed by flux tubes defines 3-D topological quantum computer program and the natural assumption is that learned behaviors are coded by the magnetic body as TQC programs. If replication of magnetic body accompanies the replication of DNA, cell, and even planaria (say), the learned behaviors are also replicated.

4. There are additional mechanisms: super-conductivity made possible by large values of h_{eff} , Josephson radiation from Josephson junctions transforming voltages to frequencies inducing

resonant transitions, and radiation consisting of dark photons and inducing cyclotron transitions serving as a basic control and coordination tools. The radiation could be generated as analog of cyclotron radiation by quantum phase transitions at magnetic flux tubes, by Josephson junctions, and by microtubules serving as quantum antennas. Frequency modulation is an excellent candidate for the representation of information: kind of whale song would be in question.

All these new notions seem to be highly relevant for the understanding the findings challenging the standard intuition discussed in the articles. It would seem that both computational aspects (TQC), self-organization but in 4-D sense, the idea about template identified in terms of flux quanta of topologically quantized classical em fields, and the local direction of quantum dynamics defined by NMP are involved rather than single principle.

The notion of time in TGD framework

The TGD based notion of time is very relevant in attempts to understand the findings about the memory of planaria and metamorphosis and metastasis challenging the standard thinking.

- 1. The general picture based on zero energy ontology
- 1. In TGD framework one must make a distinction between subjective time and geometric time: usually these times are identified. Subjective time has state function reduction/quantum jump as chronon. Geometric time is the time of physicists and corresponds to one coordinate for space-time surface or embedding space. General Coordinate Invariance implies that it is not unique but that there are very natural choices of it dictated by symmetries.
- 2. In zero energy ontology (ZEO) physical state is replaced with a pair of positive and negative energy states at opposite boundaries of $CD \times CP_2$, where CD is causal diamond identified as the intersection of future and past directed light-cones. I will talk about CD in the sequel without bothering to write "× CP_2 ". In ordinary positive energy ontology zero energy states correspond to initial and final states of physical events. The space-time surfaces having their ends at the boundaries of $CD \times CP_2$ are space-time correlate for the physical time evolution between the initial and final states. CD: s form a fractal hierarchy since the distance between the tips of CD is assumed to be integer multiple of CP_2 time. Also Lorentz transforms and translates of CD are allowed so that it makes sense to speak about moduli space of CD: s and also have "wave functions" in this moduli space. This is very relevant for understanding what the flow of time corresponds physically.

One can say, that due to the failure of strict determinism the 4-D space-time surface connecting boundaries of CD becomes the basic dynamical unit as far as subjective time development is considered. The superposition of space-time sheets is recreated again and again in quantum jump so that "quantum average" space-time - also its past - changes.

One can speak about 4-D body, brain, even society and there is continual 4-D interactions. For instance, the recall of long term memories could be communications with the geometric past using time reversed signals reflecting back from the brain of the geometric past: essentially seeing in time direction would be in question. One can even consider healing process in which the healthy state result also in the geometric past!

A new view about long term memories emerges: the brain of geometric past can serve as the seat of memories. This applies to genuine conscious memories such as episodal memories but not to learned behaviors.

3. Zero energy ontology (ZEO) implies a new view about state function reduction and about how the experience about flow of time and its arrow emerge. The state function reductions can occur at either boundary of CD but also repeatedly at same boundary. The wave function in the moduli space of CD: s with fixed "lower boundary" changes although in each repetition of state function reduction although the positive energy state at "lower" boundary remains unchanged. In ordinary quantum measurement theory nothing would change. This change gives rise to the experience about flow of time. The change is that the average temporal distance between the fixed tip of "lower" boundary and the tip of the "upper boundary" increases: essentially dispersion leading to the decay of wave packet is in question. It is analogous to diffusion in which distance of the diffusing particle from the initial position gradually increases. One can quantify this by introducing the average increase of average geometric time in single state function reduction highly relevant for understanding time experience.

- 4. Couplings between several widely different length and time scales say molecular length scale and the scale of biological body - seems to be needed in order to understand morphogenesis at least as something implied by cell level events. TGD assigns to each particle its CD. The scale of the smallest CD assignable with the particle characterized by given p-adic prime pcorresponds to its secondary p-adic length/time scale. For electron this time scale is.1 seconds defining a fundamental biorhythm: as a length scale it corresponds to the circumference of Earth.
- 5. One of the basic predictions of TGD is the failure of strict determinism of the time evolution for space-time surfaces. The interpretation is as a space-time correlate of quantum nondeterminism. The reason is the huge vacuum degeneracy of Kähler action. Any space-time surface with vanishing induced Kähler form which is essentially Maxwell field, is vacuum extremals. Mathematically this huge degeneracy is like gauge degeneracy but implies 4-D (very essential distinction from standard view) spin glass degeneracy: there is huge number of different preferred extremals obtained as deformations of the vacuum extremals. This means non-determinism.

So called vacuum functional tells the probability of one particular preferred extremal and one can imagine plotting it as a functional of the extremal. The graph would be a fractal analogous to free energy landscape of spin glass: there are minima inside minima inside.... now only the minima are replaced with maxima.

2. What healing in 4-D sense could mean?

The TGD view about time allows to imagine what 4-D healing could mean.

- 1. Suppose that one performs a deformation of the space-time sheet representing healthy organism. The system suffers "traumatic injury" in 4-D sense but only inside the CD in question. Classical non-determinism makes also possible the that the localization of 4-D deformation to a finite region of space-time rather than extending to infinite future. State functions repeatedly replace the zero energy state with a new one and it can gradually end up back to the maximum of Kähler function unless the deformation was not too large or unless it stucks to a different local maximum. If it ends up with a original maximum, one can say that 4-D healing took place. Also the biological body of geometric past is healthy! In geometric sense the system was never sick! This mechanism requires no knowledge about healthy state and no algorithm for getting back into healthy state. Nature takes care of healing.
- 2. The sticking to a local maximum of vacuum functional can prevent getting to the ideal healthy state. This can be avoided by the same mechanism as in annealing, which serves as a metaphor in numerics for a process in which one finds deep minimum of function by "kicking" the system now and then to get out of local minimum. Now the "kicking" would be stimulus deforming the system but not too much.
- 3. One expects that also Negentropy Maximization Principle (NMP) is closely involved with healing since healing should involve regain of the lost information. NMP states that the total negentropy increases in state function reductions and is apparently the opposite of second law: the negentropies in question are however not the same thing and NMP implies second law for ordinary entanglement. The implication is that the potentially conscious information associated with the negentropic entanglement (with identical entanglement probabilities for entangled states) tends to increase and negentropic entanglement (see Fig. http://tgdtheory.fi/appfigures/cat.jpg or Fig. ?? in the appendix of this book) can be only transferred to another system or transformed to a new form, but cannot disappear. Negentropically entangled systems would define kind of Akashic records storing potentially

conscious information transformed to conscious information in interaction of free quantum measurement. The approach towards maximum of negentropic and maximum of vacuum functional should closely to each other. Quite concretely, NMP could help to understand why the pieces of planaria split into two parts develop head and tail.

4. Clearly, NMP and the approach to the maximum of Kähler function both define candidates for the principles giving rise to same outcome as morphogenetic field is hoped to give. A possible interpretation is that the approach to the maximum of Kähler function is the spacetime correlate for NMP: Kähler function defined as Kähler action for preferred extremal could be regarded as classical negentropy.

3. The flow and arrow of time in ZEO

The TGD based vision about how the arrow of geometric time has developed slowly and I do not dare claim it be fully developed and final [K13].

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 relates two zero energy state basis with opposite quantum arrows of geometric time: is this assumption really consistent with what we know about the arrow of time? The second basis is always state function reduced.

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 state function reductions occurs at either of 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!

It took time to realize that zero energy states must be de-localized in the moduli space CDs (the 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.

- 3. This approach codes also the arrow of time at the space-time level: the average spacetime sheet in quantum superposition increases in size as the average position of the "upper boundary" of CDs drifts towards future state function reduction by state function reduction.
- 4. In principle the arrow of time can temporarily change but it would seem that this can occur in very special circumstances and probably takes place in living matter. Phase conjugate laser beam is a non-biological example in this respect. Memory recall [K106] would involve the change of arrow of geometric time for a subsystem corresponding to the signal propagating to the geometric past and reflecting back.

This vision involves minimal number of assumptions and is the most convincing one found hitherto and the challenge is to invent objections in order to develop it in more detail.

The notions of magnetic body and dark matter hierarchy

The notion of magnetic body is central in TGD. The TGD inspired model trying to explain the findings about microtubules by Indian research group led by Anirban Bandyopadhyay lead to rather

interesting speculations about the role of magnetic flux tubes and a more precise speculative view about how living system could act as topological quantum computer [K99] [L35].

Remark: Magnetic body is somewhat misleading term since a simple deformation implies that magnetic flux quanta carry helical magnetic and electric fields along the flux tube axis.

1. Could magnetic body define coordinate grids making possible topological quantum computation?

If the claims of Indian research group led by Anirban Bandyopadhyay are true, one can say that microtubules are macroscopically quantum coherent systems at physiological temperatures. In his Youtube talk Anirban Bandyopadhyay (http://tinyurl.com/ze366ny) [J10] discussed an identification of conduction pathways different from that of Penrose and Hameroff. In [J64] Gosh, Sahu, and Bandyopadhyay argue for evidence for massive global synchronization in brain and claim that experimental findings support the Penrose-Hameroff theory. In the article "Atomic water channel controlling remarkable properties of a single brain microtubule: correlating single protein to its supramolecular assembly" [J54] it is reported that ordered water inside microtubule is necessary for the conduction inside microtubule.

According to the same article the tubulins inside microtubule has same energy levels in chemical energy range as isolated tubulins, which suggests that the mechanism binding tubulins to form MT is not chemical. In the article "Multi-level memory-switching properties of a single brain microtubule" [J55] it is reported that the hysteresis curve for current along MT as function of voltage is ideal square curve meaning that there is no dissipation involved with the change of the current direction. This would make MT as an ideal memory device. Whether Penrose/Hameroff have in mind the use of current direction as qubit remains unclear. In video talk Bandyopadhyay refers also to these results.

I have considered the general proposal discussed in video lecture in the article [K99] [L35]. The findings reported in the talk give support for the general TGD inspired view about TQC and allow rather detailed model in the case of microtubules. The idea is that flux tubes form a 2-D coordinate grid consisting of parallel flux tubes in two different directions: the guess that they could consist of helical Fibonacci flux tubes and their mirror images is not however convincing. Crossing points would be associated with tubulins and the conformational state of tubulin could define a bit coding whether the braid strands defining coordinate lines are braided or not (swap or not). In this manner any bit pattern at microtubule defines a particular TQC program. If also conformations are quantum superposed, one has "quantum-quantum computation". It however seems that conformation change is irreversible chemical reaction [J52] so that this option is not feasible.

The TGD inspired modification of the proposal in terms of flux tube coordinate grids making possible TQC architectures with tubulin dimers defining bits defining in turn TQC program looks more plausible to me. Coordinate grids can be fixed on the basis of the experimental findings and there are 8 of them. The interpretation is in terms of different resolutions. The grids for A and B type lattices are related by 2π twist for the second end of the basic 13-unit for microtubule. An attractive interpretation for the resonance frequencies is in terms of phase transitions between A and B type lattices. If A type lattices can be generated only in phase transitions induced by AC stimulus at resonance frequencies, one could understand their experimental absence, which is strong objection against the Penrose-Hameroff model.

This would fit very nicely with the general vision about frequencies as passwords inducing not only directed attention but activities in target - also TQCs! The increase of Planck constant could be associated with the phase transition to A-phase making possible high T_c dark superconductivity for which evidence is observed! One can even deduce estimates for $h_{eff}/h = n$ if one requires that AC photons have energy above thermal threshold: $n = h_{eff}/h = f_{visible}/f_AC$ would be the estimate. For bio-photon energies one would obtain something like $n \simeq 10^8 - 10^9$, which pops up in different contexts in TGD framework.

This picture generalizes in the fractal universe of TGD. One can form layers of 2-D coordinate grids and connect them by vertical flux tubes to obtain 3-D grid defining TQC. The brain is known to have grid-like architecture and neurons could by quantum computation produce bit/qubit defining swap or not/superposition of swap and not-swap for a larger scale TQC. One would have fractal of TQCs.

A further idea is that the TQC based on 1-braids generalizes in a natural manner to 2-braid

TQC in TGD framework (for 2-braids in 4-D space-time see [K66]. The knotting occurs for string world sheets defining the orbits of braid strands - say magnetic flux tubes idealized to strings. In the case of microtubules this option suggests itself: the emergence of MTs could have meant emergence of 2-braid TQC and the increase of abstraction level in the information processing.

In the node of 3-D coordinate grid either reconnection of two flux tubes can occur or not: this is coded by one bit. Second bit tells which tube goes over which tube in the plane defined by two tubes. There are three planes of this kind corresponding to xy, xz, and yz planes, and therefore 6 bits altogether. Could genetic codon containing 6 bits of information code for what happens in the node of the grid. Note that 2-braiding is possible only if string worlds sheets "live" in 4-D space-time: for super strings living in higher-D space-time this is not possible.

This kind of 3-D TQC could be responsible for the those aspects which are nearest to computation. One must be however very cautious with the word "computation". Space-like braiding seems to be very natural for storing memories [K6] in braiding patterns ad bit patterns would characterize the 2-braiding associated with the coordinate grid but from this it is long way to computation in the usual sense of the word.

2. Flux tube grids and coding of position information

In metamorphosis and metastasis the basic problem is how the information about position is coded. How cell does know its position in organism? This is necessary for the cell to express its genome in appropriate manner: for instance, gene expression of neuron is quite different from that of muscle cell? According to the article of Levin [I105] organisms seem to have developed kind of coordinate grids to realize this purpose. For instance, simple coordinate transformations seem to related the grids of nearby species to each other. Magnetic flux tubes could be basic building bricks of these grids and at the same time the realization of morphogenetic fields. The coordinate value could be coded by the value of local magnetic field strength varying along the flux tube. By flux conservation this would correspond to the thickness of the flux tube or equivalently to cyclotron frequency. Radiation at cyclotron frequencies would act resonantly only at points at which the resonance condition is satisfied.

Voltages associated with Josephson junctions define Josephson frequencies which could be essential for bio-control and coordination via the resonance mechanism allowing selective activation of biological programs. According to [I105], the values of transmembrane potentials in frog embryo correlate with the formation of the face of Zenopus laevis embryos. The lipid layers of cell membrane are proposed to form Josephson junction (at microscopic leve the ionic channels and pumps associated with them).

Fractality suggests that nearby cell membranes - say those associated with epithelial sheets - could also form Josephson functions as fractal considerations. Gap junctions could provide a microscopic realization of these Josephson junctions. If so, then the large h_{eff} Josephson photons with frequencies determined by transmembrane potential ($f = ZeV/h_{eff}$) could induce in resonant manner activities in precisely defined positions of the magnetic coordinate grid. The radiation at correct frequency would serve as kind of password allowing to initiate a biological program. For instance, in the case considered above they could initiate the generation of the face. The errors in development could be due to various birth defects could be due to external electric perturbations. Maybe, some day even the correction of these errors might be possible by using properly tuned electric voltages.

3. What happens to the magnetic body of planaria cut into two pieces?

When planaria is cut to two pieces, second pieces regenerates head and second regenerates tail. Also when one takes second cell away from 2-cell embryo, the remaining cell becomes a full organism rather than only half of it. If there is a template for the formation of organism, then also this template must split in two. As a matter of fact, I have proposed that the magnetic body of the cell decomposes to two in cell division and that this splitting actually guides the cell division.

The fractality of TGD Universe suggests similar splitting in all scales. The vertex of Feynman diagram representing the decay of photon to electron-positron pairs provides an ultra-simplified version of the replication. In TGD framework the lines of Feynman diagrams are replaced with 4-D orbits of 3-D surfaces (or by holography 3-D orbits of 2-D partonic surfaces) and this is true in all scales. Therefore the idea that magnetic body replicates would reduce one of the most mysterious processes of living matter to generalization of fundamental physics. Note that string models do

not allow analogs for the vertices of Feynman diagrams, they are possible only in TGD framework.

The idea about magnetic body defining a coordinate grid serving as a counterpart of morphogenetic field or as template able to guide the development of the organism becomes central. It seems that even individual cell - perhaps even DNA - should contain microscopic representation of some topological aspects of the adult organism. This conforms with the notion of holography and is consistent with the central role of genes. Magnetic body with large h_{eff} being very multi-sheeted structure analogous to covering space could provide this representation. With inspiration coming from Hox genes and from deep ignorance about genetics I proposed that the magnetic body of DNA and even DNA in some rough sense could be homologous to the biological body [K73].

Can one test this hypothesis? It is also possible to isolate the cells of planaria during the development of new head by closing gap junction connections between them for about 48 hours [I105]. The outcome is planaria with two heads. As if the isolation of two cells which should have belong to the head of planaria had induced splitting of the magnetic body assignable to the head to two so that the outcome was too separate heads. One can however split the two-headed planaria again and the headless part develops now two heads! If the two headed magnetic body replicates, the outcome follows as a prediction.

Is brain really the seat of memories?

Levin and Shomrat tell about experiments demonstrating that brain is not necessarily the seat of memories as usually assumed. Planaria have brains and they are able to learn and remember. When planaria is split, the pieces develop head and tail. In the experiments planaria are taught some skill and after that split into two pieces. According to [I129], there is evidence that the part of planaria with new head remembers the skill. From this one can conclude that brain is not the only possible seat of memories.

Before continuing, it should be emphasized that memories are now defined as learned behaviors - assumed to reduce basically to conditionings of neurons at the motor areas of brain so that they generate certain motor response to sensory input. In TGD framework memories are understood as genuine conscious memories about events of past and involve communication with the geometric past.

One can imagine several explanations for the findings about the memory preservation. The computationalist possibility is that memories are transferred at least temporarily to the body of planaria and then back to the new head. This does not look biologically feasible.

Three TGD inspired explanations - corresponding to the identification of the brain of the geometric past, biological body, or magnetic body as the seat of memories - are considered.

- 1. Memories identified as conscious experiences analogous to episodal memories rather than learned skills - could reside in the old brain or biological body or even magnetic body of the planaria with new head in the geometric past and accessed by negative energy signals which are time reflected from it. This explanation is not natural when memories are identified as learned skills, which in the ideal case are un-conscious behaviors.
- 2. In TGD Universe entire body and brains could form a hologram like structure [K24] and the information about body is transferred to the new brain. This would be like hologram completion. TGD indeed suggests strongly that entire body is conscious. For instance, the sensory organs carry the primary sensory qualia, one could circumvent the problem caused by the fact that neural circuits seem the same in all sensory areas. Cortex - maybe entire brain - would build standardized cognitive mental images, give them names, and entangle them with sensory qualia at sensory organs.

Phantom leg is the basic objection against this view but new view about time allows to circumvent it: the seat for the experience about pain in phantom leg is in geometric past when the leg still existed. Note that here memories are not learned skills but memories about genuine events in geometric past. 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.

Second TGD inspired explanation for phantom leg would be it is that phantom leg corresponds to the magnetic body part: it is however not clear whether the sensation of pain even other bodily sensations can be located at magnetic body.

- 3. The long term memories of planaria restricted to learned behaviors could be represented also at the magnetic rather than biological body. Quantum computationalist would agree with this idea since learned skills would be very naturally TQC programs realized at the coordinate grid formed by the magnetic flux tubes. If magnetic body is replicated as planaria is cut to two pieces, also the TQC programs are replicated. DNA as TQC proposal [K6] assigns these programs to the braids defined by flux tubes assumed to connect DNA nucleotides or codons with the lipids of the lipid layers of the nuclear or cell membranes.
- 4. Could the state function reduction sequence implying 4-D self-organization driven by NMP lead to and asymptotic state in which also the skills learned in possession of old brain are possessed. As a matter fact, this aspect is certainly present since the replica of the magnetic body of planaria brain must give rise to original biological brain. TQC programs for the skills would be however present from the beginning.
- 5. In Zero Energy Ontology the space-time surface connecting 3-surfaces at the opposite lightlike boundaries of causal diamond are the basic objects. The maxima of Kähler function correspond to very special pairs of 3-surfaces connected by space-time surfaces. One can say that 4-D dynamical patterns, "behaviors" are fundamental objects. In ordinary ontology they would 3-D patterns perhaps interpreted as asymptotic states resulting in self-organization.

The second option looks like the most plausible explanation since allows to understand the replication of not only organism but also the TQC programs defining behavior repertoire.

Chapter 9

Are dark photons behind biophotons?

9.1 Introduction

I have written already earlier about bio-photons [K98] and proposed that bio-photons result when dark photons with large value \hbar_{eff} of effective Planck constant and large wavelength transform to ordinary photons with the same energy. The recent progress in understanding the implications of basic vision behind TGD inspired theory of consciousness [L29] [L29] served as a motivation for a complementary treatment from different perspective.

The recent progress in understanding the implications of basic vision behind TGD inspired theory of consciousness [L29] [L29] served as an additional motivation for a complementary treatment.

- 1. The anatomy of quantum jump in zero energy ontology (ZEO) allows one to understand basic aspects of sensory and cognitive processing in the brain without ever mentioning the brain. Sensory perception - motor action cycle with motor action interpreted as time-reversed sensory perception directly reflects the fact that state function reductions occur as sequences to the same boundary of causal diamond (CD) (which itself or rather, quantum superposition of CDs, changes in the process such that either the upper or lower boundaries of all CDs involved are localized at the same light-cone boundary). The first reduction of sequence corresponds to genuine state function reduction and the next induce changes only at the second boundary giving rise to experience flow of time and arrow of time.
- 2. Also the abstraction and de-abstraction processes in various scales which are essential for the neural processing emerge already at the level of quantum jump. The formation of associations is one aspect of abstraction since it combines different way to experience the same object. Negentropic entanglement of two or more mental images (CDs) gives rise to rules in which superposed n-particle states correspond to instances of the rule. Tensor product formation generating negentropic entanglement between new mental images and earlier ones generates longer sequences of memory mental images and gives rise to negentropy gain generating experience of understanding, recognition, something which has positive emotional coloring. Quantum superposition of perceptively equivalent zero energy states in given resolution gives rise to averaging. Increasing the abstraction level means poorer resolution so that the insignificant details are not perceived.
- 3. Various memory representations should be approximately invariant under the sequence of quantum jumps. Negentropic entanglement gives rise to this kind of stabilization. The assumption that self model is a negentropically entangled system which does not change in state function reduction, leads to a problem. If the conscious information about this kind of sub-self corresponds to change of negentropy in quantum jump, it seems impossible to get this information. Quite generally, if moment of consciousness corresponds to quantum jump and thus change, how it is possible to carry conscious information about quantum state?
Interaction free measurement however allows to circumvent the problem: non-destructive reading of memories and future plans becomes possible in arbitrary good approximation.

This memory reading mechanism can be formulated for both photons and photons and these two reading mechanisms could correspond to visual memories as imagination and auditory memories as internal speech. Therefore dark photons decaying to bio-photons could be crucial element of imagination and the notion bio-phonon could also make sense and even follow as a prediction.

The observation that bio-photons seem to be associated only with the right hemisphere [J48] [L28] suggests that at least some parts of the right hemisphere prefer dark photons and are thus specialized to visual imagination: spatial relationships are the speciality of the right hemisphere. Some parts of the left hemisphere at least might prefer dark phonons: left hemisphere is indeed the verbal hemisphere specialized to linear linguistic cognition.

9.1.1 Basic Facts About Bio-Photons

Alexander Gurwitsch discovered bio-photons as early as 1923 and called the phenomenon "mitotic radiation". Fritz Popp is one of those who have continued the pioneering work with bio-photons [I64, I74]. Also Roeland van Wijk [J60] should be mentioned as one of the many people involved. Recently the possible fundamental role of bio-photons in neuroscience has been realized.

To get a first quantitative grasp of bio-photons one can look at http://en.wikipedia. org/wiki/Biophotons [I6]. Ultraweak emissions of visible and also UV light from living matter. Spectrum looks continuous. Intensity (power per unit area) is 10^{-13} to 10^{-10} W/m². The intensity of solar radiation is 1.361 kW/m² and stronger by 13-16 orders of magnitude. The intensity of bio-photons is however much above the intensity of thermal radiation at energies of visible and UV photons.

In order to obtain a more biological perspective one can look for the intensity in the natural length and time scales of neuron. 2 eV is the energy of red visible photon. Using the relationship $J = 6.4 \times 10^{28}$ eV one obtains that if all bio-photons were photons with energy of 2 eV, there would be about 3.2 bio-photons per area of μm^2 characterizing cell nucleus during period of 1 ms defining characteristic time scale of neuronal firing. This raises the question whether bio-photons might be relevant for neural firing.

Chemi-oxidation via oxidative stress by reactive oxygen species (ROS) and/or catalysis by enzymes (peroxidase, oxygenase) has been suggested as a source of bio-photons [I6, I56]. The excitation of biomolecule to triplet (spin 1) state would decay via the emission of bio-photons.

Evidence has been given that bio-photons represent coherent radiation [I62, I38]. For instance, the distribution for bio-photon number for given energy is nearer to Poissonian distribution characterizing coherent state of photons (technically a state, which is an eigenstate of annihilation operator for photon of given energy and quantum analog of classical state in which it makes sense to assign classical field to the state). The coherence time from photon counts is much longer than the estimate 10^{-13} seconds based on standard sources. Time scale of at least second is nearer to reality. Also delayed luminescence (see http://tinyurl.com/ycl7515g) of bio-photons [I38] as a respose to a stimulation of system by visible photons reflects long range temporal correlations and not expected for incoherent radiation. Instead of exponential decay hyperbolic power low type decay takes place. The underlying reason is not well-understood.

The coherence is not easy to understand if chemi-oxidation is the source of bio-photons although it could quite well correlate with the production of bio-photons. The coherence and empirical findings made already by Gurwitsch have inspired the proposal that bio-photons could play an important role in control and communications in living matter. The attitudes of main-stream are very negative to proposals of this kind as the Wikipedia article (see http://tinyurl.com/yaey7ovw) [I6] illustrates. Recently the situation have been changing and reports supporting the existence of non-chemical communications (see http://tinyurl.com/abk828g) between cell cultures having no physical contact are emerging [I24].

One can raise a long list of questions about bio-photons.

1. What is the actual nature of bio-photons? If bio-photons are not primary entities (contrary to what is usually believed), what is behind bio-photons? Could bio-photons be decay products of something more fundamental and perhaps new from the perspective of recent day physics? If bio-photons are fundamental entities responsible for control and communication, the extreme weakness of their intensity becomes a problem. The idea about bio-photons as leakage of more fundamental entities could allow even metabolic role for the these entities.

- 2. How bio-photons are produced? The proposed mechanism based on oxidative stress does not explain coherence nor the reported communication and control function.
- 3. How do bio-photons or more fundamental entities relate to biology in general and specifically to metabolism, to neuroscience, to certain findings of Gariaev's group [I54], to Becker's DC currents [J17] and the related TGD inspired model discussed in [L24]? Could bio-photons relate to vision and imagination? Bischof [J83] and Bokkon *et al* [J19, J31, J74, J32, J73] have made several proposals in this respect. What is behind the correlation between EEG and bio-photons (for which multiple sources of evidence exist [J27, J51, J48] or that between the changes in bio-photon emission in meditative [J111] and qigong practices [J47, J37, J33, J43]? What about remote mental interactions, which are natural and ubiquitous if TGD-inspired biology is accepted: could bio-photons or more fundamental entities provide a control and communication tool?

The following considerations are inspired by a collection of mostly recent articles collected through Pubmed and the Qigong and Energy Medicine Database (see http://tinyurl.com/ybyyns3k) (http://www.qigonginstitute.org/html/database.php, [J6]). The purpose is to build a more detailed view about bio-photons relying on ideas represented already earlier [K70, K98].

The basic vision involves some new elements: bio-photons are decay results of dark photons, which are the fundamental objects. Dark photons play a key role in non-destructive reading of sensory/cognitive/memory representations by interaction free measurements. Besides dark photons and also dark phonons could be involved in interaction free measurements and could be behind imagination resp. internal speech. Hence the notion of biophonons deserves a serious consideration. Dark photons and maybe also dark phonons would be generated by the memory reading mechanism automatically as a kind of echo and could yield virtual sensory input allowing to test whether sensory representation is realistic. Also copies of memories would be produced automatically by the echo mechanism: this could explain after-images and serve as a basic mechanism of learning. Dark photons could also serve communication and control purposes and define metabolic energy, making possible remote metabolism by what I have called quantum credit card mechanism. The energy range of biophotons corresponds to visible and UV range so that they are optimal for biochemical control by inducing molecular transitions.

9.1.2 Basic Ideas Of TGD Based Model Of Bio-Photons

The following list summarizes the key TGD inspired ideas about bio-photons.

1. Identification of elementary particles microscopically.

Quantum antenna hypothesis suggests that bio-photons are associated with topological light rays - "massless extremals" (MEs, topological light rays [K91]). Biophotons - in fact, all elementary particles - are identified as pairs of wormhole contacts with wormhole contacts connecting two space-time sheets in CP_2 directions. The two space-time sheets would be most naturally ME and magnetic flux quantum (tube or sheet). These details do not matter much for applications.

2. Identification of bio-photons as decay products of dark photons.

In TGD Universe bio-photons would be ordinary photons resulting from the transformation of dark large $\hbar_{eff} = n \times \hbar$ low frequency (f_l) photons to ordinary photons with high frequency (f_h) . In the original form I proposed (f_l, f_h) pairing as what I called scaling law of homeopathy [K62], and later realized the connection with the hypothesis about hierarchy of Planck constants. This transition would transform low frequency dark photons with E= $h_{eff} \times f_l$ to ordinary photons with $E= h \times f_h$ ("I" is for "low" and "h" is for "high"). The outcome could be observed as bio-photons. Any system having field body with parts having large \hbar_{eff} can generate dark photons in turn decaying to bio-photons or dark photons with smaller value of \hbar_{eff} . Decay cascade decreasing \hbar_{eff} down to \hbar is the most general option and the integers n in $\hbar_{eff}(k)/\hbar = n(k)$ are factors of n(1). This is a strong number theoretical prediction. The longest possible decay sequence to ordinary photons would factorize the integer $n = \hbar_{eff}/\hbar$ so that this kind of process might also have number theoretical meaning.

The low intensity of bio-photons suggests that the rate for the transformation of ordinary to dark is very low and/or that the density of charged particles (say ions of cyclotron BE condensate) generating dark photons is very low. Given a quantitative model for the mechanism one could estimate the rate for the transformation of ordinary photons to bio-photons. Gariaev's experiment [I54] yielding radio wave photons (interpreted as dark photons) from incoming laser light beam irradiating DNA sample could help to estimate the transformation rates as function of h: the most naive guess inspired by scaling argument is $1/h_{eff}$ dependence for given photon energy. DNA would induce energy conserving transformation of ordinary laser photons to long wave length dark photons with the same energy. A possible mechanism is modulation of the beam by radio wave frequency.

The crucial parameter is the magnitude for the $f_l \to f_h$ transition amplitude. Dimensional analysis suggests that the rate $\Gamma(f_l \to f_h)$ is proportional to f_l . This would give very slow rate for ELF frequencies so that the intensity of bio-photons would be very low l for a given intensity of dark photons.

The intensity of dark photons could be rather high. Gariaev reported the transformation of laser light to radio waves in scattering from DNA in rather wide range of frequencies [I54]. These photons had biological effects on remote target (stimulation of growth of potatoes). If radio frequency photons are dark photons with visible energies they could have provided metabolic energy for high enough intensity. The role of controller is also possible. Dark photons could be also used to read memory representation in non-destructive way by interaction free measurements so that dark photons would be fundamental from the point of view of cognition.

The value of not only h_{gr} but also that of h_{eff} at magnetic flux tubes could be proportional to the mass of charged particle populating the flux tube in question. Flux tubes would distill the molecules to separate flux tubes. Cyclotron energy scale would be universal and does not depend on the mass of charged particle: therefore bio-photons would have universal energy spectrum in the range of molecular excitation energies.

3. Possible connection with negentropic entanglement.

The connection of dark photons with negentropic entanglement is not well understood but highly suggestive. One can imagine at least three reasons for the connection, which are not necessarily exclusive.

- (a) If the braiding (geometric entanglement!) of magnetic flux tubes carrying dark matter and dark photons (!) serves as a correlate for negentropic entanglement, braided collections of flux tubes define negentropically entangled systems serving as negentropy sources. This fits nicely with DNA as topological quantum computer vision [K6] and with the vision about various representations (sensory, motor, memory,...) [L29]).
- (b) Dark photon with $\hbar_{eff} = n \times \hbar$ with frequency f_l can be said to contain *n*ordinary photons with frequency f_l . Could these analogs of ordinary photons be negentropically entangled?
- (c) An alternative view is that dark photons are necessary for generating quantum coherence and negentropic entanglement in long length scales. This option is consistent with the first two options.

Note: Topologically dark photons correspond to the *n* sheets of *n*-fold covering of space-time sheet assignable to *n*-furcation reflecting the failure of the strict determinism of Kähler action for preferred extremals. One might even ask whether dark photon with energy E could be seen as space-time correlate of Bose-Einstein condensate of photons with energy E/n!

4. Some signatures of bio-photons in TGD Universe.

The simultaneous presence of frequencies f_h and f_l is the basic signature of the proposed mechanism. Cyril Smith [J21] has done a lot of work with this kind of connection and claims that $f_l \leftrightarrow f_h$ transformations (interpreted as transformations between dark and bio-photons in TGD framework) occur in living matter. His interpretation is completely different. Smith mentions the frequency ratio $f_h/f_l = 2 \times 10^{11}$ as very special one. For $\hbar_{eff}/hbar = 2 \times 10^{11}$ radiation with $l_l = 2.56$ kHz would correspond visible photon with $\lambda = .6 \ \mu m$ at the red end of the spectrum.

Assuming that bio-photons indeed appear in TGD Universe, the first predicted signature is a correlation between fluctuations in EEG power and the ultraweak emission of visible photons from brain identified as particular kind of bio-photons. This kind of correlation has been observed [J27] but visible photons emerge from right hemisphere [J48].

- (a) Could this mean that right brain and left hemisphere emit dark photons in different energy ranges: one possibility is that left hemisphere emits infrared photons above the thermal energy. The photons would have energies above the Josephson energy $E_J = 2eV_{rest} = .12$ eV in case of Cooper pairs of electrons. Here $V_{rest} \simeq .06$ V denotes the membrane resting potential are possible infrared analogs of bio-photons.
- (b) The idea that dark photons correspond to imagination and dark phonons to internal speech in turn would suggest that left brain as brain hemisphere responsible for internal speech operates with dark phonons rather than dark photons. Right hemisphere being specialized to spatial thinking would favor dark photons.

Second signature are long range temporal correlations reflecting the origin of bio-photons. These correlations are observed for bio-photons as delayed luminescence [I38] and the sequel presents a model for the correlations based on dark photons explaining hyperbolic decay law and suggesting a totally unexpected connection with zeros of Riemann zeta.

9.1.3 Are Biophonons Also Predicted?

It came as a surprise that a general model for the non-destructive reading of memory mental images and their time reversals (interpreted as predictions of the future based on interaction free measurement) in principle allows the use of not only dark photons, but also *dark phonons* in the reading process. The mechanisms of imagination and internal speech could emerge from the general structure of quantum jump and model for self representation based on negentropic entanglement.

The identification of bio-photons as decay products of dark photons suggests strongly that biophonons also result as decay products of dark phonons. Internal speech could be one manifestation of the transformation of dark phonons to ordinary ones. This transformation could also appear as a dissipative leakage phenomenon.

As a pleasant surprise came the realization that there is a poorly understood phenomenon of this kind known as Taos hum [I84]. The patient suffering from it hears an unpleasant humming sound reflecting the properties of the acoustic environment but which does not generate any response in microphones. Nevertheless neurophysiological correlates for hearing the Taos hum are observed.

Taos hum is experienced only after and before sunset. The electric "static" (electrical noise in shortwave radio receivers) beginning after sunset and believed to have a biological origin has been proposed to at least correlate with this phenomenon. A natural interpretation would be that when vision is not a possible communication tool anymore, dark photons or dark phonons propagating along ME-flux tube pairs are used for communications. Since living matter is full of electrets dark photons or phonons can give rise to the static.

Several options can be considered: dark signal could propagate from the source to receiver as dark photons or phonons along ME-magnetic flux tube pair, continue by travelling along MEflux tube pair parallel to the auditory pathway down to the ear as dark photons or phonons and transform then to ordinary phonons generating the experience. The most conservative option consistent with the earlier proposal that the distinction between right and left hemispheres relates to the wave length range of dark photons (bio-photons in left hemisphere would be in infrared) [L28]. It seems that Taos hum is experienced in a pathological situation: a possible interpretation is that the leakage of dark phonons to bio-phonons is too strong and leads to the experience. Also the electromagnetic component of the patient's immune system could fail and negative energy dark photon signals could suck metabolic energy from the patient.

I will consider a slightly modified briefer version of a model that I developed for Taos hum for more than a decade ago as evidence for the notion of magnetic body [K70] (sensory magnetic canvas was the term that I used at that time). In this model Taos hum was interpreted as a phenomenon analogous to microwave hearing. At the end I will consider variants of the model involving dark photons and/or dark photons.

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 [L31].

9.2 Bio-Photons In TGD Universe

I have discussed already earlier the identification of bio-photons in TGD framework [K24, K98].

9.2.1 The Origin Of Bio-Photons In Standard Physics Framework

The are several proposals for the source of bio-photons: for instance cell membrane [I51], DNA [I62], mitochondria [I66], linear molecules [I100], microtubules are proposed as sources of bio-photons. The existence of several sources conforms with the universality of production mechanism.

- 1. Biophotons seem to be emitted under stress [I96]. It has been proposed that bio-photons arise as a product of redox reactions of free radicals [I6, I56]. The hypothesis is motivated by the correlation between bio-photon counts and doses of reactive oxygen and nitrogen species but does not explain in any obvious manner the coherence of bio-photons. The proposed production mechanism is that a biomolecule is excited to a triplet state (spin 1) and releases photon as it returns to the ground state. Laser like behavior would be required in order to achieve the coherence. The correlation of bio-photon production with ROS can however have alternative explanations.
- 2. A model for bio-photon production based on non-linear polarizable double layers obeying Maxwell's ED: cell membrane is proposed [J73]. Destructive interference between incoming and reflected wave leaving a wave confined inside double layered structure.

9.2.2 The Origin Of Bio-Photons In TGD Universe

Dark photons decaying to bio-photons could be produced by many systems - even non-living systems. Therefore the production mechanism of bio-photons would be universal and there would be several dominating production mechanisms for bio-photons. One test for this is to check whether water and quartz crystals produce bio-photons (the claimed health effects of quartz crystal might be real and relate to dark photons).

In the framework of standard biology one would try to identify biochemical mechanisms for the production of bio-photons. The coherence of bio-photons however suggests that something totally new is involved. Just the assumption that something genuinely new is involved of course sounds rather outlandish unless one has a concrete proposal for what this new is and unless this something new is able to solve other puzzles.

Do dark photons give rise to biophotons?

The basic philosophy in what follows will be as following. In computer world decomposition to hardware and software is very useful. In biology this division could mean that biochemistry describes dynamical hardware and also the mechanisms modifying it. Electromagnetic fields in TGD sense, dark photons, magnetic body, topological quantum computation, communications and control by dark photons would correspond to software. If this division is real, one might have rather satisfactory description of the software without even mentioning biochemistry. "Biology is governed by symbolic dynamics" is other manner to state the idea: to predict the behavior of priest all that one needs to know that he/she is a priest. One could never predict the behavior of priest from biochemistry and Newton's laws but single word "priest" associated with his person allows this. The basic justification for this separation between software and hardware (biochemistry) would come from the identification in terms of dark matter having now direct interactions with ordinary matter (in the sense that particles with different value of \hbar_{eff} cannot appear in interaction vertices.

- 1. In TGD framework the counterpart of confinement inside double layered structure in polarizable media proposed as a model for bio-photons [J73] is confinement of photons inside topological light rays (MEs) acting like wave guides. Mechanism can be said to be gravitational since MEs are not only extremely non-linear structure but as space-time quanta also gravitationally non-trivial. The deviations of TGD from Maxwell's electrodynamics (MED) are important and come from induced field concept implying also topological field quantization. For instance, MEs are analogous to wave guides and have no counterpart in MED. MEs can carry non-vanishing light-like currents not possible in MED. MEs mediate precisely targeted signals propagating with light velocity without changes in their shape, to only single direction. Therefore MEs are ideal for communication and control. Topological field quantization makes space-time topology in various scales a key player also in biology. This leads to the notion of magnetic body and also the notion of electric flux quanta such as cell membrane.
- 2. In TGD Universe the large value of \hbar_{eff} provides a general explanation for macroscopic quantum coherence. This allows several sources of bio-photons resulting when dark photon transforms to ordinary photon of same energy.
 - Dark photons could be absorbed and emitted in cyclotron transitions at magnetic flux tubes. Dark photons could be Josephson photons from a Josephson junction formed by the lipid layers of cell membrane. The minimal energy for the Josephson photon assignable to electronic Cooper pair is $E = 2eV_{rest} = .12$ eV for electronic Cooper pair and $V_{rest} = .06$ eV and is above thermal threshold. More generally, the spectrum of dark photons would be a combination of cyclotron spectrum and Josephson spectrum assignable to cell membrane [K48]. Frequencies would come as sums of harmonics of cyclotron frequency for a given bosonic ion or Cooper pair of fermionic ions and harmonics Josephson frequency.
 - The variation of the membrane potential induces a modulation of Josephson photon frequencies $f_J = ZeV$. This suggests that frequency modulation defines the fundamental information representation. This brings in mind whale's song maybe mathematically very similar to human speech (as hearing in as slowed down version reveals) in various time scales!
 - Huping Hu has observed that dipole magnetic interaction between protons with distance of 10 nm corresponds to energy scale in EEG frequency scale [J71] [L28]. Large \hbar_{eff} could raise the energy to visible range. The cyclotron transitions assignable to the pairs of dark protons forming analogs of Cooper pairs could generate dark photons with EEG frequency and cytochrome oxidase could catalyse the energy metabolism providing them energy.

One can raise several questions about dark photons and bio-photons.

1. How are dark photons generated? Gariaev's experiments [I54] suggest that at least DNA induces transformation of ordinary photons to dark photons with much lower frequency. Could amplitude modulation of f_h signal by f_l signal provide a mechanism producing $\hbar_{eff} = f_h/f_l$ dark photons decaying to bunches of ordinary f_l photons or to ordinary f_h photons? Resonance condition requires integer valued frequency ratio and in principle this could serve as a test. In many experiments, say the pioneering experiments of Blackman and others (see for instance [J23]), this kind of modulation is involved. If this mechanism really works it provides a tool for producing dark photons: this has an obvious technological potential.

- 2. How would reactive oxygen species induce $\hbar_{eff} \rightarrow \hbar$ transitions inducing a loss of coherence? The process should be the inverse for the generation of dark photons. Analog of induced emission: presence of ordinary photons of same energy in state would increase the rate for the transition $\hbar_{eff} \rightarrow \hbar$. What is the reverse of amplitude modulation? Small ripples in a slowly varying wave. Amplitude modulation with frequency much higher than modulated frequency. Are these two descriptions equivalent?
- 3. What is the connection with quantum antenna hypothesis [K91]? Pairs of MEs and magnetic flux tubes giving rise to structures parallel to linear structures populating biosystems (axons, microtubules, DNA, linear molecules, etc) could be involved. Larger space-time sheet would induce a modulation by lower frequency defined by its scale. A hierarchy of amplitude modulations would be the outcome.

Has the decay of dark photons to visible photons observed in astrophysical scales?

There is an interesting news providing new light to the puzzles of dark matter in New Scientist (see http://tinyurl.com/y9r65xnh). It has been found that Universe is too bright. There are too many high energy UV photons in the spectrum. The model calculations suggest also that this too high brightness has emerged lately, and was not present in the early universe. The intergalactic space contains more neutral hydrogen and thus also more ionized hydrogen as thought previously and it was hoped that the ionized hydrogen could explain the too high brightness. It is now however clear that 5 times more ionized hydrogen would be required than theory allows accepting the experimental data.

The question is whether dark matter could explain the anomaly.

- 1. The usual dark matter candidates have by definition extremely weak interactions not only with ordinary matter and also with dark matter. Therefore it is not easy to explain the finding in terms of ordinary dark matter. The idea about dark matter as remnant from the early cosmology does not fit naturally with the finding that the surplus UV radiation does not seem to be present in the early Universe.
- 2. In TGD dark matter is ordinary matter with large $h_{eff} = n \times h$ and has just the ordinary interactions with itself but no direct interactions with visible matter. Thus these interactions produce dark radiation with visible and UV energies but with probably much lower frequencies (from $E = h_{eff}f$). The energy preserving transformations of dark photons to ordinary ones are an obvious candidate for explaining the surprlus UV light.
- 3. These transitions are fundamental in TGD inspired model of quantum biology. Biophotons are in visible and UV range and identified as decay products of dark photons in living matter. The fact that the surplus has appeared recently would conform with the idea that higher levels of dark matter hierarchy have also appeared lately. Could the appearance of UV photons relate to the generation of dark matter responsible for the evolution of life? And could the surplus ionization of hydrogen also relate to this? Ionization is indeed one of the basic characteristics of living matter and makes possible charge separation [L36], which is also a crucial element of TGD inspired quantum biology [K101]

9.2.3 Biophotons, Dissipation, And De-Coherence

1. By above proposal the yield of bio-photons would be a leakage process. The transformation of dark photons to ordinary or dark photons with smaller \hbar_{eff} means reduction of coherence length of order wave length by the ratio of final and initial effective Planck constants. The process leading to visible photons leads to a coherence length which is fraction of micron. Therefore also dissipative effect is in question. The ordered energy of dark photon BE condensate transforms to less ordered energy of ordinary photons.

The process is expected to reflect the long scale coherence of dark photons. This could resolve the basic objection against the observation of delayed luminescence for which time scale should be of order 10^{-13} seconds for standard value of \hbar . Scaling of \hbar to \hbar_{eff} can increase this time scale even to seconds if not longer time scales.

In the simplest mode the intensity of bio-photons is proportional to the intensity of dark photons proportional to the modulus squared for dark photon complex order parameter assignable to a coherent state of dark photons. Also other than coherent states are possible: for instance, Popp *et al* have suggested so called squeezed states (see http://tinyurl.com/ y9qbh6nr) [I65].

- 2. Cancer could be understood as a disorder in which \hbar_{eff} of part of magnetic body is reduced to smaller value and eventually to its ordinary value of \hbar so that long range coherence is lost. If dark photons have energy of visible photons, basic coherent units have size of cell and one obtains "selfish cells" [I76].
- 3. Redox reactions, ROS and RNS induce loss of coherence by inducing process reducing \hbar_{eff} and production of bio-photons: perhaps by the inverse of amplitude modulation which might generate dark photons. These reactions could have also a useful role in hardware development. Kind of etching of 4-D brain as a representation of self (modification of synaptic connections for instance) might be the basic function and necessarily involves dissipation.

9.2.4 What Is The Origin Of The Hyperbolic Decay Law?

The basic question concerns the origin of the hyperbolic decay law. It is not actually clear whether this law as anything to do with genuine decay or whether it reflects the behavior of complex order parameter of dark photons as a function of time. The latter interpretation is supported by the following argument.

The intensity decays slowly being in the first approximation of form $I(t) = I(0)/(1 + \lambda t)$: also hyperbolic waves of form $I_0 sin(log(1 + (t/t_0)))$ have been reported. The most general form for the intensity is

$$I(t) = I(0) \times exp(\lambda u) , \qquad (9.2.1)$$

where $\lambda 1 + iy$ is complex parameter and $u = log(1 + \lambda t)$ is the analog of time coordinate defined as logarithm of the shifted and normalized dimensionless time coordinate $T = (t + t_0)/t_0$. Fractal power law $I \propto T^{\alpha}$ approaching for large values of t to $I(t) = t^{\alpha}$ would be in question.

In zero energy ontology (ZEO) this kind of behavior can be related to Lorentz invariance.

- 1. The boundary of CD corresponds to light-cone boundary with light-like coordinate. For irreducible representations of Lorentz group the wave functions at light-cone boundary t = r (c = 1 in the units used) behave as r^{α} . The appearance of this coordinate might be due to the fact that dark photons travelling with light-velocity are involved.
- 2. For hyperboloids $t^2 r^2 = a_0^2$ one would have wave functions behaving as

$$A_y(t) = A_0 \times u^s$$
, $s = -1/2 + iy$, $u = (\frac{t^2 - a_0^2}{a_0^2})^{1/2}$. (9.2.2)

The intensity would be of the form

$$I_y = \frac{A_0^2}{u} \tag{9.2.3}$$

approaching the hyperbolic form for $t >> a_0$. For $a_0 = 0$ one obtains exact power law behavior $I \propto t^{-1}$.

3. Oscillatory behavior is obtained if one has superposition of two waves of this kind with different values of y:

$$A = \cos(\phi)A_{y_1} + \sin(\phi)A_{y_2} \tag{9.2.4}$$

giving

$$I = \frac{1 + \sin(\phi_1 + \phi_2) \times \cos[(y_1 - y_2)\log(u)]}{u}$$
(9.2.5)

approaching hyperbolic decay law for $t >> a_0$ and diverging for $t = a_0$. Linear combinations $\sum a_n A_{y_n}$ are also possible.

What is intriguing that the form of the complex parameter s is same as for the zeros of Riemann zeta.

- 1. There are several reasons to believe that the zeros of Riemann zeta might play fundamental role as "scaling momenta" in TGD framework [K110]. For instance, if the spectrum of wave vectors associated with the zeros of zeta is discrete and consists of logarithms of integers so that the zeros of Zeta define quasilattice, Riemann hypothesis holds true [K110]. Furthermore, discrete spectrum for the zeros is strongly favored by number theoretical considerations since it gives hopes about p-adic algebraic continuation of the integral by reducing it to sum for both zeros of zeta and for the Fourier transform.
- 2. The quantization of spectrum for the distribution defined by zeros of Zeta means that the spectrum of "momenta" is integer valued in suitable units. In the recent case the momenta correspond to values of the radial coordinate r so that only the integer values $r = nr_0$ are possible. The interpretation would be in terms of discretization of the radial coordinate r and also of time. This is just what number theoretic vision suggests and the notion of p-adic manifold (see appendix of the book) requires both at real and p-adic side.
- 3. This argument would suggest that hyperbolic scaling law at light-cone boundary actually corresponds to a distribution

$$A(u) = \sum_{y} A_{y}(u) , \ u = \frac{t}{t_{0}} .$$

localized to the values $u = t/t_0 = r/r_0 = n$. This implies automatically infinite number of interefence terms in the intensity $I(u) = |A(u)|^2$ and the comparison of $I(t/t_0)$ with the experimentally determined intensity of bio-photons serves as a killer test for the proposal since only one parameter - t_0 determining the scale - appears in the model.

9.3 Do Dark Photons Transform To Bio-Photons?

The following text is based on comments about the article Quantum and Holistic Response of Human Skin to H_2O_2 Stimulation by R. P. Bajpai, A. Rastrog and A. Popp to be published in Journal of Nonlocality (JNL).

The notion of bio-photon is now well-established and there is a lot of activity in this field. It is becoming clear that bio-photons might be highly relevant for brain functions as the correlations between fluctuations associated bio-photon emission and fluctuations of EEG. Some examples of experimental work relevant to what follows are bio-photon emission from hand [I122], the effect of hydrogen peroxide H_2O_2 on bio-photon emission from radish root cells [I121], and delayed luminescence of leaves [I123]. R. Bajpai has discussed a squeezed state description of spectral decompositions of a biophoton signal [I124, I36]. This proposal is highly interesting from TGD point of view, which relies on the notion magnetic body carrying dark matter as large $h_{eff} = n \times h$ phases identified as dark matter. Magnetic body would control living matter by its "motor actions" such as changing the thickness of a flux tube carrying monopole flux so that the strength of magnetic field and therefore cyclotron frequency changes. Dark cyclotron photons could transform to ordinary photons with the same energy identified as bio-photons and bio-photons could be seen as a kind of leakage.

Squeezed photon emission relies on a modification of harmonic oscillator mass or frequency or both meaning that the original vacuum state becomes many-photon state. The fact that the cyclotron states of charged dark matter at magnetic flux quanta indeed are essentially harmonic oscillator states suggests that the "motor action" of the magnetic body consisting of the change of flux tube thickness induces the emission of squeezed dark photons with wavelengths scaled up by $h_{eff}/h = n$ in turn decaying to bio-photons with a universal energy spectrum if the conjecture equating h_{eff} with gravitational Planck constant $\hbar_{gr} = GMm/v_0$ introduced by Nottale: $h_{eff} = h_{gr}$ indeed implies that the dark photon cyclotron spectrum does not depend on the mass of the charged particle.

This model would explain the coherence of bio-photon emission in macroscopic and macrotemporal scales. Bio-photon emission would reflect the decay of dark photons to ordinary photons identified as bio-photons. Hyperbolic decay law corresponds to exponential decay law with respect to logarithmic of time variable bringing in mind renormalization group: this replacement could reflect the fact that a scaling of causal diamond (CD) is identifiable as the geometric counterpart of subjective time in TGD inspired theory of consciousness.

9.3.1 Basic Ideas

In the following I try to summarize what I have understood about bio-photon emission.

- 1. Bio-photon emission is induced by some external stimulus, which can be light or stress of some kind, say chemical stress such as hydrogen peroxide (H_2O_2) stimulation. The signal is ultraweak and broadband so that spectroscopy is difficult. The signal is analyzed in time domain by dividing the time interval into pieces with duration say 3 minutes and deducing photon number distribution, average photon number, and variance for each interval. The variation of the interval length is used to deduce whether signal can be modelled semi-classically as being produced by independent transitions of molecules or whether "quantum entity" is responsible for the signal. The average signal strength is constant but there are fluctuations inside bins.
- 2. The interpretation proposed in the article is in terms of squeezed photons: this state has minimum quantum un-certainty - that is the product $\Delta x \Delta p$ for canonically conjugate variables associated with the signal has the smallest possible value consistent with Uncertainty Principle. I understand that there is a constant average signal plus a slowly decaying tail representing the reaction of "quantum entity". The temporal coherence in long time scales is one motivation for "quantum".
- 3. Bio-photon signal would be produced by a decaying squeezed state with long lifetime and with hyperbolic rather than exponential time dependence. Similar model applies also to biophoton signal generated by a dose of light: according to the article these two signals have 3 identical squeezing parameters. A further parameter having interpretation as a strength of response is not universal. Also delayed luminescence gives rise to similar signal. The suggestion is that in all cases some "quantum entity" reacts to the stimulus: chemical stress in the case of H_2O_2 stimulation.
- 4. The alternative interpretation based on semiclassical model assuming that statistically independent molecular transitions produce the signal does not allow to understand the signal: for instance an exponential decay rate is predicted and the response should reflect the molecular transitions involved. Also constant value of average signal strength is difficult to understand semi-classically.

There is a nice article about squeezed light at http://tinyurl.com/y97r7eda [B6].

- 1. The mathematics behind the notion is that of harmonic oscillator with slowly varying mass and frequency parameters. The vacuum state of oscillator is one example of squeezed state with minimum momentum position uncertainty (for photons photon number-phase uncertainty). Coherent state of oscillator obtained by applying resonant driving force is second example of squeezed state.
- 2. A general squeezed state is characterized by complex squeezing parameter $R = e^r$, and phase angle ϕ mentioned also in the article. Besides this there is angle θ telling the rotation made for the counterpart of spatial coordinate before squeezing so that squeezing is maximal for θ . To my understanding θ and ϕ describe essentially the same thing but I am not sure.
- 3. For amplitude (phase) squeezed state the position (momentum) uncertainty is minimized below that for harmonic oscillator vacuum state but Uncertainty Principle forces the increase of width of the distribution for phase. Now these canonically conjugate variables correspond to photon number and phase angle analogous to the rotation angle of harmonic oscillator rotating in position-momentum plane.
- 4. There is also a parameter called displacement (α): this parameter characterizes the displacement of the position of harmonic oscillator vacuum occurring already for harmonic oscillator under resonant oscillator force for which potential is linear on position and momentum: the stronger the force, the larger the displacement. Unlike $(r, \theta, \phi) \alpha$ does not seem to be universal. The value of the displacement $|\alpha|$ would naturally characterize the strength of the stimulus modelled as a resonant oscillatory external force.
- 5. Squeezing can be described formally in terms of an exponential of a squeezing operator analogous to an oscillator Hamiltonian. Squeezed state is defined by its exponent giving rise to a formal time evolution to be not confused to real time evolution of squeezed state which can be created by a sudden scaling of the parameters of oscillator Hamiltonian preserving the area in position-momentum plane.

The peculiar feature of squeezed light is that in frequency domain photons appear as pairs in the sense that the state is superposition of states with even photon number.

6. Time dependent parameters in oscillator Hamiltonian is one manner to produce squeezing (http://tinyurl.com/y89mvsnu. The vacuum state for harmonic oscillator becomes squeezed state when (say) the frequency of the oscillator becomes time dependent. In the simplest situation the oscillator frequency could suddenly change to some other value. I have an impression that this kind of sudden change of oscillator Hamiltonian induced by the external stimulus is assumed to make vacuum state a squeezed state.

With respect to new oscillator Hamiltonian the vacuum state is squeezed state that is superposition of many-photon states with even photon number. Squeezing in the most general case is time-dependent symplectic transformation preserving the area in position-momentum plane and as a special case one can have time dependent modulation of harmonic oscillator mass and frequency, now photon frequency. The modulation would very slow as compared to photon frequency for ordinary value of Planck constant.

9.3.2 The Key Challenge

Introduction discusses also what authors of and also I see as a key problem.

- 1. Some mechanism must provide the energy for quantum entity so that it can generate biophoton signal or something generating bio-photon signal. This is mentioned in introduction as the basic unsolved problem. It is not at all obvious how (and even whether!) universal energy quantum of about 5 eV and considerably below the bio-photon range beginning at about 1 eV (visible and UV).
- 2. Two mechanisms have been proposed: explicit and implicit. Explicit mechanism involves chains of chemical reactions of reactive oxygen species helping to gather metabolic energy to that of molecules (up conversion). The signal would reflect the chemical properties of biomolecules in the chain involved. Implicit signal would be signal coming from quantum entity and depend on its states and evolution of the response of quantum entity to the stimulus.

3. The conclusion is that the explicit mechanism is not favored and that implicit mechanism produces squeezed state. The challenge is to identify the "quantum entity" and understand whether it provide the metabolic energy directly or helps to transform ordinary metabolic energy to that of bio-photons. Also one must understand how the "quantum entity" receives its energy - presumably from Sun too.

9.3.3 What I Did Not Understand

There were many things that I failed to understand, basically due to the lacking background knowledge about squeezing.

- 1. What the estimated values of r and ϕ (equivalent with θ ?) are? It would be nice to have something about this in introduction. An illustration of time evolution of a squeezed state would help enormously. A brief summary of definitions of basic parameters as Appendix would help enormously non-specialist reader.
- 2. The oscillator Hamiltonian involves oscillator frequency. What is the value of this frequency now and how it relates to the photon frequency? Can it be equal to photon frequency for visible light or does it perhaps correspond to the time scale for oscillation in squeezing (phase rotation). Or can this frequency be interpreted in terms of amplitude modulation.

I saw in Wikipedia an example in which the variation of phase uncertainty corresponds to a period of 10-100 ms. This is bio-logical time scale range. It would be nice to have a comment about the value and possible origin of the slow time scale associated with the squeezing since it would naturally relate to the time scale of macro-temporal quantum coherence.

9.3.4 TGD Inspired Comments

Some TGD inspired comments are in order since the squeezed light would be very naturally be induced by "motor actions" of magnetic body.

Do motor actions of the magnetic body induce squeezing?

- 1. TGD predicts a hierarchy of Planck constants $h_{eff} = n \times h$ and suggests that cyclotron frequency modulation is one of the key mechanisms in living matter. For instance, the variation of membrane potential would induce modulations of generalized Josephson frequency which is sum of difference of cyclotron frequencies and the ordinary Josephson frequency $f_J = 2eV/h_{eff}$. The modulation of the frequency and amplitude of harmonic oscillator to yield time dependent symplectic transformation is one mechanism producing slowly varying squeezing. Low frequency modulation of this kind could produce also dark photons which according to TGD inspired proposal would transform to ordinary photons with same energy identified as bio-photons.
- 2. In TGD framework the squeezed state would be that of dark photons with $h_{eff} = n \times h$ and much larger than ordinary Planck constant to guarantee that VLF or even ELF frequencies correspond to energies in the range of bio-photon energies $(E = h_{eff}f)$. This must be taken into account when if one tries to model the situation. The large value of h_{eff} would explain the slow time scale of squeezing naturally. For the ordinary value of Planck constant the time scale of squeezing is gigantic as compared to the natural time scale assignable to visible photons (about ten femtoseconds).
- 3. An instantaneous change of the frequency of harmonic oscillator produces squeezed state. The change of the thickness of the magnetic flux tube would change the value of magnetic field strength (by flux conservation) and thus of cyclotron frequency $\omega = ZeB/m$. This would affect the oscillator frequency (cyclotron states can be regarded as harmonic oscillator states) so that the outcome would be squeezed state. Do "motor actions" of magnetic body induce squeezed photon states? Does magnetic body react to stimuli by changing the thickness of its flux tubes?

4. Could a phase transition changing the value of Planck constant induce a squeezed state? The answer is negative. If the scalings $x \to nx$ and $\omega \to \omega/n$ take place in the phase transition $h \to n \times h$ as has been assumed then $h \to n \times h$ respects the property of being energy eigenstate property and vacuum goes to vacuum.

The following comment is not directly related to squeezing but to possible interpretation of phase transitions changing Planck constants as singular symplectic transformations (symplectic group of $\delta M_+^4 \times CP_2$ is isometry group of "world of classical worlds" (WCW).

- 1. Magnetic flux is invariant under symplectic transformations defined by magnetic field for the surface over which it is taken. These symplectic transformations have nothing to do with those of phase space since they act at the level of space-time. One can still ask whether transformations analogous to basic squeezing could make sense.
- 2. A especially interesting choice of symplectic variables corresponds to the choice of cylindrical coordinates (ρ, ϕ) . The symplectic transformation $(\rho, \phi) \rightarrow (\rho/a, a \times \phi)$ for a = n would scale does the thickness of the flux tube by integer n and increase the angular range from 2π to $n \times 2\pi$. A possible interpretation is that one obtains a multi-sheeted covering by allowing the original variable ϕ to have range $n \times 2\pi$.
- 3. What makes this interesting is that just this kind transformation is assumed to take place in the transition $h \rightarrow h_{eff} = n \times h$ and lead to n-fold singular covering of space-time surface. Could the phase transition increasing Planck constant correspond geometrically to a singular symplectic transformation leading to n-fold covering and radial scaling at the level of space-time?

What is behind the hyperbolic decay law of the squeezed state?

One should also understand the hyperbolic decay law of the squeezed state.

1. What causes the slow hyperbolic decay of the squeezed state? Hyperbolic decay corresponds to the exponential decay $dN/d\tau = -kN + R$ but with time variable u which is logarithm of ordinary time variable: $\tau = log(1 + t/t_0)$ (note the convention u(t = 0) = 0). This gives decay law

$$N(t) = N(0) \times \left[1 + \frac{t}{t_0}\right]^{-k} + \frac{R}{k}$$

For k = 1 one obtains $x \propto 1/t$ hyperbolic behavior for large values of t. Somehow the ordinary linear time is replaced by its logarithmic variant.

2. In TGD framework the decay would correspond to the gradual decay of dark photons to ordinary photons. The decay kinetics for dark photon number N_D and bio-photon number N_B would be described by two equations:

$$\frac{dN_D}{du} = -kN_D + R$$
 , $dN_B = kN_D$, $u = log(\frac{t}{t_0} + 1)$.

The rate for emission of bio-photons would be now

$$\frac{dN_B}{dt} = kN_D(0)\left[1 + \frac{t}{t_0}\right]^{-k} + R$$

k = 1 gives hyperbolic decay law. Note that the rate approaches to the rage R of dark photon production: constant background intensity of bio-photons has been indeed observed.

- 3. What is the mechanism replacing the time coordinate with its logarithm in the decay law? The logarithmic behavior strongly suggests a connection with a renormalization group approach relying on scaling invariance: the extension of 2-D conformal invariance so that it makes sense in 4-D context is indeed the basic symmetry of quantum TGD. Time evolution would correspond to scaling. Scale invariance implies that the logarithm of the scale appears as an evolution parameter in renormalization group evolution. Zero energy ontology would suggest that time coordinate corresponds to the scale characterizing the size of causal diamond (CD) and that time evolution for the bio-photon emission corresponds to a quasi-continuous scaling of CD.
- 4. In TGD inspired theory of consciousness the correspondence between subjective time and geometric time reduces basically to the identification of time evolution as subsequent scalings of CD occurring in repeated state function reductions, which would in ordinary quantum measurement theory leave the state invariant.

Where do bio-photons get their energy?

The basic problem of bio-photon scenario is the mechanism providing the metabolic energy for bio-photons. Ordinary metabolic energy quantum is around 5 eV and below visible energies.

- 1. In TGD the quantum entity would be magnetic body with hierarchical onion-like structure with layers, whose sizes can be even larger than that of Earth. Cyclotron frequency defines time scale and for large $h_{eff} = n \times h$ the frequency of cyclotron photons can be even in ELF range (say in EEG range). h_{eff} would thus scale up the time scale of coherent and the values of h_{eff} deduced earlier are so large that it could be measured in time scales assigned to EEG.
- 2. In TGD framework one can consider the possibility that cell membrane as generalized Josephson junction and in microscopic description membrane proteins acting as generalized Josephson junctions generate dark photons in visible and UV range and these in turn transform partially to ordinary photons identifiable as bio-photons. Could ordinary metabolism excite the dark cyclotron Bose-Einstein condensed (like laser in population reversed state)?
- 3. Or could the magnetic body associated with the bio-systems receive this energy directly from Sun: as ordinary solar photons transform to dark photons at magnetic body. I have considered a mechanism for creating CDs (not causal diamonds now but coherence regions of water of size of order micrometer suggested by Vitiello and Del Giudice (http://tinyurl.com/yagy3fcu) [I47]). Inside CDs were water molecules would be excited to energies slightly below the bond energies in the exclusion zones (EZs): the difference would be just the metabolic energy quantum.5 eV.

Metabolic energy quanta could generate EZs of size of large neuron by splitting O-H bonds and giving rise to $H_3/2O$ stoichiometry inside EZs. My own crazy proposal is that the UV energy about 12 eV comes directly from Sun as ordinary photons and travels as dark photons along flux tubes of magnetic body to the organism and partially transform to biophotons. This model can be generalized to include dark photons covering entire spectrum of bio-photons (there is an argument predicting that the spectrum of dark photons is universal and that of bio-hotons). A precise model for energy balance might help to conclude that "quantum entity" providing additional metabolic energy must be there.

For year or two ago there was a discussion in Journal of Non-Locality about people claimed to be able to receive their metabolic energy from solar radiation and just for fun I considered a model based on dark photons and involving same mechanism as appears in metabolism. I also remember of having seen years ago a paper about problems in attempts to understand energy balance in brain but do not remember more about this.

Squeezing and entanglement

A very interesting variant of squeezed state mentioned in http://tinyurl.com/y97r7eda [B6] is two-photon squeezed state. In this state the amplitude to begin with is product of two vacua, which is unentangled state. The other vacuum is squeezed up in position by R and other one down by 1/R. This produces entangled state, which is highly interesting bio-logically: could this entangle "quantum entity" and the receiver of the radiation? Is it possible to interpret the findings about bio-photons in terms of two-photon squeezing?

9.4 How Could Dark Photons And Phonons Relate To Consciousness?

One of the basic objections against the identification of moment of consciousness as quantum jump is that contents of consciousness corresponds always to change. How it is possible to code anything about the states of the world if this is the case? For instance, how conscious entity can construct a self model which by definition should correspond to something which is approximately invariant in quantum jump sequences? Negentropically entangled subsystems indeed can be parts of the state approximately invariant under dynamics dictated by Negentropy Maximization Principle (NMP) [K80].

The manner to circumvent the objection comes from the notion of interaction free measurement: the conscious information about invariant part of system, say self model, could be obtained by interaction free measurement, which involves state function which leads the incoming photons to interaction free state. This information would be obtained as sequences of bits and might be correspond to declarative, verbal memories rather than direct sensory experiences.

9.4.1 What Does Bomb Testing Have To Do With Cognition And Consciousness?

Dark photons decaying to bio-photons could be involved with the basic cognitive processes like memory recall involving interaction free measurement. At the ideal limit the photon which interacts with a subsystem representingbit of memory mental image suffers state function reduction to a path at which it does not interact with the memory system in the usual sense. Hence memory mental image is not affected at all at this limit. The following model for memory recall is discussed in the article "A Vision about Quantum Jump as a Universal Cognitive Process" (see http://tinyurl.com/yc46pq86) [L25]

1. The bomb testing problem of Elitzur and Vaidman gives a nice concrete description of what happens in interaction free measurement, see http://tinyurl.com/kx2jsyu [B2] for illustration of the system considered.

The challenge is to find whether the bomb is dud or not. Bomb explodes if it receives photon with given energy. The simplest test would explode all bombs. Interaction free measurement allows to make test by destroying only small number of bombs and at idealized limit no bombs are destroyed.

The system involves four lenses and two detectors C and D. In the first lense the incoming photon beam splits to reflected and transmitted beams: the path travelled by transmitted beam contains the bomb.

- (a) The bomb absorbs photon with a probability which tells the fraction of photon beam going to the path at which bomb is (is transmitted through the lense). The other possibility is that this measurement process creates a state in which photon travels along the other path (is reflected). This photon goes through a lense and ends up to detector C or D through lense.
- (b) If the bomb is dud, photon travels through both paths and interference at the lense leads the photon to detector D. If C detects photon we know that the bomb was not a dud without exploding it. If D detects the photon, it was either dud or not and we can repeat the experiment as long as bomb explodes, or C detects photon and stop if the detector continues to be D (dud). This arrangement can be refined so that at the ideal limit no explosions take place and all.

2. The measurement of bomb property is interaction free experiment in the sense that state function reduction performed by absorber/bomb can eliminate the interaction in the sense that photon travels along the path not containing the bomb. One might say that state function reduction is an interaction which can eliminates the usual interaction with photon beam. State function reduction performed by bomb can change the history of photon so it travels along the path not containing the bomb.

This picture is only metaphorical representation of something much more general.

- 1. In TGD framework the photon paths branching at lenses correspond to branching 3-surfaces analogous to branching strings in string model and photon wave splits to sum of waves travelling along the two paths.
- 2. Bomb could be of course replaced with any two-state system absorbing photons in one state but not in the other state, say atom. Now one would test in which state the atom is gaining one bit of information in the optimal situation. Two-state atom could thus represent bit and one could in principle read the bit sequence formed by atoms (say in row) by this method without any photon absorption so that the row of atoms would remain in the original state.

Memory recall as an interaction free measurement

One can imagine several applications if the information to be read in interaction free manner can be interpreted as bit sequences represented as states of two-state system. Lasers in ground states and its excited state would be analogous many particle quantum system. In TGD framework the analog of laser consisting of two space-time sheets with different sizes and different zero point kinetic energies would be the analogous system.

For instance, a model of memory recall with memories realized as negentropically entangled states such that each state represents a bit can be considered. The model applies also to the reading of future plans (memories on reversed time direction).

- 1. Reading of a particular bit of memory means sending of negative energy photon signal to the past, which can be absorbed in the reading process. The problem is however that the memory representation is changed in this process since two state system returns to the ground state. This could be seen as analog of no-cloning theorem (the read thoughts define the clone). Interaction free measurement could help to overcome the problem partially. Memory would not be affected at all at the limit so that no-cloning theorem would be circumvented at this limit. Memory bit to be read would be mathematically analogous to bomb in the Elizur-Weizman bomb tester thought experiment in which one tries to determine whether bomb is active (bit 1) and can therefore explode or passive (bit 0) and cannot explode.
- 2. A possible problem is that the analogs of detectors C and D for a given qubit are in geometric past and one must be able to decide whether it was C or D that absorbed the negative energy photon! Direct conscious experience should tell whether the detector C or D fired: could this experience correspond to visual quale black/white and more generally to a pair of complementary colors?
- 3. ZEO means that zero energy states appear have both embedding space arrows of time and these arrows appear alternately during periods of repeated state functions having no effect at the other boundary of CD. This dichotomy would correspond to sensory representationmotor action dichotomy and would suggest that there is no fundamental difference between memory recall and future prediction by self model and they different only the direction of the signal.
- 4. Since photon absorption is the basic process, the conscious experience about the bit pattern could be visual sensation or even some other kind of sensory qualia induced by the absorption of photons. The model for the lipids of cell membrane as pixels of a sensory screen suggests that neuronal/cell membranes could serve defined digital self model at the length scale of neurons.

Some comments are in order.

- 1. To avoid misunderstandings it should be emphasized that TGD based view about memory is not the same as the standard view. In ZEO brain is four-dimensional and in principle memories can be negentropically entanglement memories in geometric past. It is possible to build copies of memories by memory recall, and learning would correspond to a generation of large enough number of copies of the memory mental image. Memory recall could be seen as a negative energy signal inducing the interaction free measurement of memory qubits. Dark photons with EEG frequencies (say in theta band characterizing hippocompus) but having energies of visible photons could be involved with the memory recall. Correlation between EEG and bio-photons supports this view.
- 2. If the systems taking the role of the detectors C and D in interaction free measurement are analogous to population reversed lasers, their return to the ground state could automatically generate virtual sensory input propagating to the sensory organs and allowing to check whether it is consistent with the actual sensory input. The generation of the feedback signal takes some time expected however to be much shorter than that for a typical neuronal activity.

Since the signals would propagate with light velocity, the virtual sensory input could travel practically instantaneously from the brain to sensory organs and possibly also vice versa. Libet's experiments on passive aspects of consciousness [J42] in fact demonstrate a time delay which is fraction of second having interpretation in terms of time to propagate to a layer of magnetic body of size scale of Earth and back: these delays are consistent with the fact that the chronon of sensory experience is about.1 seconds. The propagation of photon signals in both directions would make possible construction of sensory representation in time scale much shorter than that of neural activity. This mechanism could also explain generation of after images.

3. Photons can be replaced with phonons or quanta of any other wave motion with constant propagation velocity (no dispersion of signal) in a given reference frame. This suggests that imagination and internal speech correspond to the two reading mechanisms of memories.

9.4.2 Why Vision And Hearing Are So Fundamental For Cognition?

The interaction free measurement of bits of sensory and memory representations is formulated in terms of photons. It can be however formulated also for sound waves using phonon detectors and acoustic waves traversing through two different paths. Quantum coherence is required but the hierarchy of Planck constants makes sense also for phonons by the basic equation E = hf.

In TGD framework there are good reasons to believe that sound waves are not only something emerging at the level of condensed matter but correspond to oscillations of string like objects at 4-D space-time surface. These strings connect the wormhole contacts assignable to the light-like orbits of partonic 2-surfaces. Partonic 2-surfaces can be assigned with elementary particles but also to 2-surfaces with arbitrarily large size scale. The outer boundary of any physical object would correspond to a partonic 2-surface. String world sheets carry fermion fields localized at them (right-handed neutrino is an exception in that it is de-localized at entire space-time surface). The fact that strings always connect two partonic 2-surfaces corresponds to the fundamental twoparticle character of sound waves. Sound would be as fundamental phenomenon as photons and other massless bosons.

This encourages to ask whether photon (more generally gauge boson: TGD suggests that scaled up copies of gluons and weak bosons behaving like massless particles even in cell length scale are possible) and photon absorption could define fundamental potentially representations of information in terms of bits realized in terms of interaction free measurements. Negentropic entanglement at the passive boundary of CD would define another representation, which is directly conscious. Negentropic entanglement is possible also at active boundary but is not absolutely stable.

Photons would correspond to "seeing" but at neuronal level rather than at the level of retina - and imagination. Phonons would correspond to hearing at neuronal level and internal speech which is also essential for cognition. Both internal speech and imagination could be understood at fundamental aspects of cognition. Dark photons with energies of visible photons (decaying to what is interpreted as bio-photons) and dark phonons would be behind imagination and internal speech. I have already earlier proposed that the lipid layers of neuronal membranes (and maybe also ordinary cell membranes) can be regarded as pixels of a sensory map representing neuronal qualia [K59]. These pixels could serve as the counterparts of the detectors C and D appearing in interaction free measurement.

The evidence for the importance of bio-photons (in TGD framework dark photons decay to bio-photons in energy conserving manner) in biology and neuroscience is emerging, see for instance the experiments of Persinger's group [J48, J49, J50]. I have discussed these findings from TGD point of view in [L28]. One can speculate about direct translation between the words of language and visual pre-images. Something like this one might expect.

Biophotons seem to be associated only with the right hemisphere [J48]. This suggests that right hemisphere or some parts of it prefer dark photons being thus specialized to visual imagination in accordance with the fact that spatial relationships are the speciality of right hemisphere. Could this mean that left hemisphere or some pats of it prefer dark phonons? Left hemisphere indeed is the verbal hemisphere specialized to linear linguistic cognition and produces also internal speech.

9.4.3 Dark Photons, After Images, And Mechanism Of Learning

After images are generated when one stares to bright light source for some time. Anyone can observe how the after images develop. After images drift gradually downwards suggesting that they are indeed generated at the retina and their source drifts downwards in gravitational field. After image also reappears periodically and can change their color in each re-appearance.

It has been suggested that bio-photons could be responsible for the generation of after images. In TGD framework the after images would be generated by dark photons decaying to bio-photons.

- 1. Delayed luminescence has been proposed as explanation. The light absorbed by retina from intense light-source emitted partially as bio-photons could define the secondary source. This is a possible mechanism since retina is sensitive to even single photon. One can however ask what is the real mechanism behind delayed luminescence.
- 2. Consciousness theoretic explanation based on the model fo sensory receptor as an analog of capacitor which suffers di-electric breakdown. There is some recovery time. Looking into bright light-source generates visual sensation but requires a long recovery time. The image is regenerated after the recovery. Visual mental images define conscious entities (selves) and just as we do they also would have sleep-awake cycle). Where the sensory input comes or do bio-photons resulting in the decay of dark photon BE condensates generate it. Why the periodic appearance and why the gradual change of color? Could it be that the photons rotate in a large loop identifiable as a closed magnetic flux tube? Does the time constant (length of loop) for a visual receptor depend on the peak frequency for which it is sensitive.
- 3. Or is a generation of copies of visual memory in question? Magnetic body or brain generates a virtual sensory input as dark photons transforming to bio-photons at retina. Internal speech involves similar echo like effect and also piece of music is recalled repeatedly. Could delayed luminescence provide a mechanism of memory storage: the repetition of the stimulus increases the probability of memory recall in TGD based model of long term memory as a communication with the geometric past?

As a matter fact, delayed luminescence could be seen to reflect the presence of a deeper level cognitive mechanism rather than vice versa. The periodic appearance of after images could be a process in which retina receives periodically a virtual sensory input - perhaps from magnetic body via brain - and generates as a response nerve pulse pattern, and perhaps also dark photons generating a memory mental image which is negentropically entangled with the earlier memory representation.

In this process memories representing the after image are read and the interaction free measurement involved with the process excites laser like systems which then generate radiative response defining the virtual sensory input, which then generates genuine sensory input. One could speak of a repeated echo. Why the color of the after image changes could be understood if the decay of the laser like states generates photons with several energies.

Similar echo generating mechanism for dark phonons instead of photons could explain why during sleep and also during wake-up state some word of internal speech repeats itself.

9.4.4 Realization Of Memory Representations In Terms Of Braided Flux Tubes

The obvious question is how various representations (sensory -, memory -, ...) - "Akashic records" - are realized as negentropically entangled states?

Magnetic body should be the seat of memories in some sense.

- 1. I have already earlier proposed this kind of realization based on the observation that braiding in time direction generates space-like braiding [K6]. Dancers on the parquette with their feet connected to the wall by threads illustrates the idea. When dancers move at the parquette their world lines define a time-like braiding in 3-dimensional space-time assignable to the floor. Also the threads connecting the dancers to the wall get braided - or entangled - as one might also say. There is clearly a duality between time-like and space-like braidings: the running topological quantum computer program coded by braiding in time direction is stored as space-like braiding defining memory representation of what happened. Note that same mechanism realizes also predictions and future plans as time reversed topological quantum computer programs in ZEO. CDs in various scales contain this kind of programs and their memory representations.
- 2. I have also proposed that the geometric entanglement braiding of flux tubes defines a spacetime correlate for quantum entanglement. In the case of topological quantum computation it would be naturally described by probabilities, which are rational numbers (or perhaps even algebraic numbers in some algebraic extension of p-adic numbers characterizing together value of the p-adic prime the evolutionary level of the system). Hence the notion of number theoretic negentropy makes sense and one obtains a connection with topological quantum computation.
- 3. The representation of memories in terms of space-like braiding of magnetic flux tubes connecting various systems would be universal, and not restricted to DNA-cell membrane system in which the flux tubes would connect DNA nucleotides [K6, K138] or codons (this seems to be the more plausible option [L28]) with the lipids. One could indeed speak about Akashic records (http://tinyurl.com/5hxjpr).
- 4. The time reversals or these representations defined by the zero energy states of opposite arrow of the embedding space time would define a representation for future predictions/ plans in ZEO. For instance, the development of a seed to a full-grown organism could be coded in this manner in time scale where CD has time scale of order of the lifetime of the organism. Already Burr found evidence that the radiation field assignable to the seed has the same shape as the plant [I91, I101] or animal (salamander in his experiments). This energy field would naturally correspond to the magnetic body containing dark photon Bose-Einstein condensates. The Akashic records and their time reversal would naturally correspond to the morphic fields of Sheldrake [L19, I120]: memories and future plans in time scales longer than than duration of life cycle for an individual member of species would be possibles. Every scientist of course agrees that the societies are busily predicting and planning their futures but find very difficult to accept the idea that this could have some concrete quantum physical correlate.

9.4.5 How To Construct And Read Conscious Hologram?

There is also another question to be answered. How the vision about brain as a conscious hologram is realized in the proposed conceptual framework?

The idea about living system as a hologram has strong empirical basis. One of the most dramatic demonstrations of the hologram like character of brain was the discovery of Pietch [J94]

that salamander's brain can be sliced to pieces and shuffled like a deck of cards and put together. When the resulting stuff is returned to the head of the salamander, it recovers! This extreme robustness is very strong support for the non-local hologram like storage of biological information. Ironically, Pietch tried to demonstrate that the theory of Karl Pribram [J80, J81] about brain as a hologram is wrong!

In TGD framework one can go even further and ask whether this robustness actually demonstrates that various representations (sensory - , cognitive -, memory -...) are realized at the long magnetic flux loops and sheets of the magnetic body rather than brain: one of the most disptable ideas of TGDi based quantum biology.

The notion of conscious hologram [K24] is one of the key ideas of TGD inspired theory of consciousness. Hitherto I have not been however able to find a really convincing concrete proposal for how brain could be a hologram in TGD Universe. The reading of memory - and other representations by interaction free measurement however leads to a natural proposal for what the hologram might be.

- 1. The formation of the hologram must closely relate to the vision about bit representations of memories possibly realized in terms of braided flux tubes and their non-destructive reading by interaction free measurement. Oversimplifying, tor a given bit of the representation the photons scattered without interaction would kick either of the two detectors C and D associated with it to an excited state (see http://tinyurl.com/y86ysuyd). This process is very much like absorption of photons by a photosensitive plate defining an ordinary hologram.
- 2. The lipids of the cell membrane are good candidates as something in 1-1 correspondence with the basic units of this hologram (note the analogy with computer screen - also a liquid crystal!). If one irradiates the laser like system formed by the detectors not only by the radiation scattered from the memory bits sbut by its superposition with the reference wave of same frequency, one obtains a good candidate for a hologram. It would be defined by the excited quantum state consisting of laser systems analogous to the detectors C and D. Any piece of the system should give and approximate representation of the memory and robustness of the representation is achieved.
- 3. In semiclassical treatment the probability that a given laser like detector is excited must be proportional to the modulus squared of the net field amplitude, which is a superposition of reference wave and scattered wave Also just. as in the case of ordinary holograms, the irradiation of the laser like system by the negative energy counterpart of the reference wave (its phase conjugate emitted in a state resulting in state function reduction to the opposite boundary of CD) effectively generates the conjugate of the scattered wave since only those parts of the system can return to the ground state with considerable probability for which the probability to go to excited state is high enough. Note that this implies that magnetic body contains geometric representations of the perceptive field as indeed assumed [K70, K71]. This is however not quite the classical hologram. Rather, the total number of absorbed negative energy phase conjugate photons for given pixel defines the "real" picture. A given point of the hologram corresponds to an ensemble of laser like detectors so that a statistically deterministic response is obtained as an ensemble average.

How to realize this concretely?

- 1. The lipids of cell membrane could serve as pixels of sensory representations [K59] defining conscious holograms. Each pixel should contain large number of laser like "detectors" so that statistical determinism would be achieved.
- 2. The basic structural element would be pair C and D of detectors such that either of them absorbs photon in an interaction free measurement so that a value of bit is defined. Universality serves as a strong constraint as one tries to guess what C and D could be.
 - (a) The lipids at the two lipid layers of cell membrane could be in 1-1 correspondence with C and D. This option is not however universal.

- (b) It is however quite possible that the magnetic fields involved are what I have called wormhole magnetic fields [K147], which carry monopole fluxandinvolve two space-time sheets carrying opposite net fluxes. As a matter of fact, all elementary particles correspond to flux quanta of wormhole magnetic fields. In this case the two sheets would naturally correspond to detectors C and D and in the simplest situation they would have same Minkowski space projection. Universality of both detectors and holograms is achieved.
- 3. The cyclotron Bose-Einstein condensates for charged particles at magnetic flux tubes assignable to lipids are good candidates for the laser like systems if they contain cyclotron Bose-Einstein condensates. There are however several options since the magnetic flux tubes are closed and there are several ways to realize this.
 - (a) DNA as topological quantum computer vision [K6] and the view about cell membrane as a sensory receptor communicating data to the magnetic body in turn sending control signals via DNA suggest the following. Magnetic flux loops have a part connecting DNA with nuclear or cell membrane (this would be the analog for the dipole of the dipole magnetic field) and part which is long - even with size scale of Earth and corresponds to the magnetic field created by the DNA-cell membrane system. This picture applies both to the flux tubes of ordinary magnetic field and to the flux tubes of the wormhole magnetic field.
 - (b) An assumption in accordance with the general role of magnetic body is that Akashic records reside at the short portions of flux tubes connecting lipids with DNA codons: their braiding would define basic example about universal representations in living matter. The laser like detectors would reside at the long portions of the flux tubes connecting cell membrane and DNA. If wormhole magnetic fields are in question, the detectors C and D could correspond to the two parallel flux tubes carrying opposite monopole fluxes.
 - (c) Universality suggest that this picture allows many alternative realizations. In principle, the relative motion of any system (partonic 2-surfaces with light-like orbits) connected by flux tubes could give rise to Akashic records. The lipids of axonal membrane are excellent candidates for the pixels and the flux tubes connecting the lipids to microtubuli [J2] would also define Akashic records with long parts of the flux tubes serving as the laser like system. The maximization of the memory capacity would also explain why the neural pathways to brain tend to maximize their lengths by connecting right side of the body to left hemisphere and vice versa.
- 4. What remains still open is how to integrate the Josephson junctions defined by the lipid layers of the cell membrane to this picture.

9.4.6 Some Critical Questions

There are two basic objections against quantum theories of consciousness. How it is possible to have conscious information about invariant under quantum jumps if only change is experienced continuously? The outcome of state function reduction in standard quantum theory is random: how can one understand freedom of choice and intentional behaviour in terms of state function reduction? NMP and the possibility of negentropic entanglement (see **Fig. http://tgdtheory**. **fi/appfigures/cat**.jpg or **Fig.**?? in the appendix of this book) imply that TGD based quantum theory is not equivalent with the standard one, and this allows to circumvent the objections.

The experiments carried out to test whether 40 Hz thalamocortical resonance is correlate for conscious experience suggests that the resonance is present only when a new pattern is discovered, not when it has become a memory. The TGD inspired interpretation would be that the resonances accompanies negentropy gain and quantum jump is necessary for a conscious experience. However, the reports about higher states of consciousness suggest that the invariants can be experienced directly when all thoughts (interaction free measurements) are eliminated. This experience cannot be however communicated: one understands does not know what one understands. Therefore also the original vision that negentropic entanglement corresponds to a conscious experience - experience of pure understanding, which is not communicable - and in apparent contradiction with

the basic hypothesis about quantum jump, would be correct after all! Only the identification of the hierarchy of quantum jumps as self hierarchy would be wrong.

9.5 Taos Hum As Evidence For Biophonons?

Taos hum is an experimentally well-established anomalous phenomenon which has escaped rational explanations (in the article [I84] a thorough review about nocturnal taos hum is given and the following representation relies on this article). Very concisely, taos hum seems is apparently a subjective experience without identifiable objective counterpart, and could therefore correspond to dark photons and/or phonons eventually transforming to ordinary sound and generating the experience. In the following basic facts about taos hum are summarized and some alternative TGD inspired explanations of taos hum are considered besides the original explanation as microwave hearing.

9.5.1 Basic Facts

Taos hum is perceived in and around Taos, New Mexico but similar phenomena are experienced also in Northern America and Northern Europe. The hum is mostly heard during night time. Most people experience the hum as irritating and it causes nocturnal disturbances. From the tests based on psychophysical matching the frequency range of the hum has been deduced to be 40-80 Hz and whereas amplitude is around 60 dB. The hum is a regional phenomenon. The hum does not usually appear between sunrise and sunset. The pitch and intensity of the hum varies inside house and finds the largest magnifications on lower floors. Rooms modify the hum by adding distinctive harmonics to it. The pitch of the hum changes when one moves from outer wall to the interior rooms. Hallways and small alcoves raise the pitch considerably. The wavelengths involved vary between 3.9-7.8 meters for 40-80 Hz frequency range which suggests that resonance effects could be involved. It has been however impossible to identify any acoustic origin for the phenomenon. The presence of effectively acoustic effects suggests that a gigantic amplification by the physical (and magnetic!) body of the patient is involved.

Hum can involve also an experience about whirling or roaring wind, kind of vortex although nothing moves around, and coming from all directions. Also a strange amplification of distant sounds can be experienced. White light in the horizon in the direction where hum comes from can be also perceived. Experiences analogous to hum have been reported also in past, even in antique ("Aeolian wind"), but nowadays the number of victims of the hum has increased, which suggests a connection with the emergence of electronics and computers. The direction which hum is experienced to come from seems to be random.

The hum can be accompanied by irritating tactile sensations and neuralgic pain. The unfortunate individual who suffers of extreme HUM disturbances, seems to be controlled by very fundamental and autonomic response-reflexes when in it grips. Such sufferers may behave in semiconscious modes, modelling behavioral patterns seen only in animals. Typically the victim tends to get underground believing that this allows to get him rid of the hum. The victims of hum indeed tend to wake up with the realization that they have very strong and painful muscle tenure.

An important hint as regards to mechanism of hum is the fact that the temporal patterns of the shortwave radio static detectable by shortwave receivers correlate strongly with those associated with the hum. It is also known that the static has a biological origin: the warbling sounds characterizing the static resemble those produced by plants and galvanic skin response sensors. And most importantly, the statics is present during night time.

All attempts to detect the hum instrumentally and to identify its source have failed. This has inspired various kinds of conspiracy theories about the nature of the phenomenon, for instance, the proposal the strong ELF power feed by submarine radars alone could explain the phenomenon.

9.5.2 Phenomena Possibly Related To Taos Hum

It is appropriate to discuss first some phenomena possibly related to the taos hum before considering the model for the phenomenon itself.

Microwave hearing

Microwave hearing [I58] is a phenomenon in which microwaves generate an audible sensation. There is evidence that microwave hearing does not involve ears as receivers of the primary signal [I40] and that the sensation of hearing could result as back-projection from cortex to ears.

This, and the correlation with microwave static suggest that taos hum could be a particular case of microwave hearing. The model of sensory representations implies that brain acts as a sending microwave antenna: a natural implication is that brain can act also as a receiving microwave antenna. The size of the brain hemisphere corresponds to a microwave frequency of order 3 GHz and smaller structures inside brain correspond to higher radio frequencies.

If primary sensory organs are the seats of the sensory qualia and back-projections cannot induce physical pain, the presence of the painful tactile sensations means that microwaves - assuming that they underlie Taos hum - also must interact also with the sensory receptors at the skin.

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 $h_{eff} = n \times h$ [?] 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!

Physiophonic effect

Physiophonic effect is a phenomenon accidentally discovered by Antonio Meucci in 1842, in which vocal signals are electrically transmitted directly into the neurology of listeners [I84]. Physiophonic sound can be often amplified to an enormous volume. A possible interpretation is as externally stimulated internal sound but one can of course wonder whether the transduction to sound is necessary.

Since the body (especially collagen network) is liquid crystal allowing piezoelectric effect in which mechanical vibrations are transformed to electric signal, external sounds could be transformed to electric fields. On course, LC property implies that also genuine sound is generated so that both ELF em fields and ELF sounds can act as amplified signals. One can ask whether strong back-projection to the ears is generated so that sound percept results. This would imply oto-acoustic sounds directly detectable by microphones not found in the case of taos hum.

Microwave static and taos hum

It is known that the temporal patterns of the shortwave static detectable by shortwave receivers correlate strongly with those associated with the hum. It is also known that the static has a biological origin: the warbling sounds characterizing the static resemble those produced by plants and galvanic skin response sensors. And most importantly, the fact that the static is present during night time would explain why hum is experienced at night time.

9.5.3 Possible Ingredients For The Model For Taos Hum

The facts about the role of the musculature, shortwave radio noise, and the role of acoustic environment combined with the model of microwave hearing based on the notion of dark photons [K68] pose strong constraints on the model of taos hum.

Taos hum as sensitivity to external biological control signals

Magnetic bodies control biological body by sending control commands to brain and body where they are transformed to nerve pulse patterns and various physiological waves. Also the lower levels of self hierarchy should control the respective levels of the hierarchy, in particular muscle cells, in a similar manner. In the case of hum patient the normal control signal could be replaced by a control signal from some external biological source, say plants, and would be responsible for the muscular vibrations amplified to the hum. In the worst situation the behavior of hum patients reduces to simple reflex actions: these reflex actions would be initiated by fake control signals.

The fact that the taos hum begins after the sunset would conform with the interpretation as sucking of metabolic energy with energy quanta in visible and UV range. The loss of metabolic energy could explain why the experiences of patients are so unpleasant. Since motor action is based on negative energy signals affecting directly neuronal membranes by the same mechanisms as ordinary motor actions the signals would also induce reflex actions.

The situation could be due to the failure of the em (or rather, electro-weak) immune system of the patient. In order to understand what is involved a brief discussion of model of motor control based on charge entanglement induced by W MEs is necessary: a detailed model is discussed in [K62, K68].

- 1. The exotic ionization of dark matter induced by W MEs generates dark plasma oscillations inducing electric fields which by many-sheeted variant of the Faraday law induce electric fields also at the space-time sheets where ordinary matter resides. Various ionic waves, in particular Ca²⁺ waves and nerve pulse are examples of the physiological responses resulting in this manner.
- 2. Dark plasma frequency corresponds to a microwave photon with energy above the thermal threshold and the system must be able to provide dark photons with this energy to generate plasma oscillation patterns serving as control commands.

The electro-weak immune system could fail in the following manner.

- 1. In the healthy situation em immune system takes care that the body is tuned to the personal dark plasma frequencies and does not respond to control commands from alien magnetic bodies associated with, say, plants.
- 2. In an un-healthy situation persons plasma oscillation frequencies are tuned to some frequencies in the microwave static and microwave static provides the energy needed to generate plasma wave patterns and thus to realize control commands from the alien magnetic bodies. The plasmoids would induce microwave hearing and generalized motor actions at cellular level exhausting the personal metabolic sources and leading to the painful experiences and fatigue.

Taos hum and microwave hearing

The identification of the audible sensation associated with taos hum in terms of microwave hearing could explain the failure of the attempts to identify the source for taos hum. Amplitude modulation by ELF frequencies naturally associated with motor control would give rise to sensation of sound.

Concerning the model for microwave hearing, a good guideline is that the effect is expected to be possible as quantum effect only if the energies of the microwave photons are above the thermal threshold. This would require dark microwave photons for which 5 GHz photons have energy above thermal threshold (6 cm wavelength). Same applies to other effects caused by dark microwave photons.

Microwave hearing itself would rely on hearing of dark microwave photons at visible and UV frequencies. These dark microwave photons could accompany the microwave signal automatically or could be generated by cells via a phase transition increasing the value of Planck constant.

Taos hum and microwave seeing

The de-coherence of microwave photons to ordinary photons would produce the biological effects. This could explain also the reported perception of white light as resulting from the de-coherence of the microwave photons at the upper end of the spectrum: 1 mm microwave wavelength would correspond to 2.5 eV photon energy.

The de-coherence of dark microwave static to ordinary visible photons could make possible microwave vision during night time. This could explain why the static emerges after the sunset.

Plants could also generate negative energy dark microwave photons with energies in the frequency bands of visible photons involved with photosynthesis to satisfy their metabolic needs when they do not receive sunlight. One can of course wonder whether the quartz in the rock heated during day-time could generate dark microwave photons during night-time serving as a metabolic source.

Taos hum as a failure of the electromagnetic immune system

Taos hum starts immediately after the sunrise and stops after the sunset and seems to have a biological origin. The magnetic bodies of (say) plant cells could send dark energy photons at microwave frequencies above 5 GHz: one reason is that they become visible in this manner.

Negative energy W MEs in the same frequency range and responsible for quantum bio-control in the time scale of microwaves could be involved. Due to the failure of the electro-weak immune system the surrounding biosphere could induce generalized motor actions and these would exhaust the metabolic energy resources of the victim. This would explain why the hum is intolerable and the extreme fatigue caused by it.

The radio noise generated by computers and other sources of radio waves should not cause troubles if these radio waves correspond to ordinary photons. If not, then the microwaves in question could provide the energy needed to realize alien control commands based on ELF modulation.

An explanation for 40-80 Hz modulation

The model of biological evolution and evolution of nervous system based on dark matter hierarchy [K48] leads to sa detailed identification of the values of Planck constant associated with EEG identified as of dark Josephson radiation with energies in visible and UV range and EEG frequencies. This level is involved with all life forms capable of genetic expression, in particular plants. Therefore the ELF modulation of microwave frequencies could be due to the control commands from the levels of the magnetic body normally meant to control the genetic expression of say plants. The modulation of the microwaves with EEG frequencies, in particular with the frequencies in the 37 - 44 Hz thalamo-cortical resonance band, could force the patient to stay awake by not allowing the dominant EEG frequencies to drop down to theta and delta region of EEG as occurs during sleep.

Is stochastic resonance involved?

One could also ask whether the microwave static of victims of taos hum is anomalously amplified by some mechanism so that control commands from alien magnetic bodies can be realized. The transduction of weak microwave signals to mechanical oscillations by piezo-electric body liquid crystals, and the amplification of this signal in the presence of a metabolic energy feed to the musculature, could lead to this kind of situation.

Stochastic resonance with white noise generated by body provides one possible amplification mechanism. Micro-wave frequency would correspond to the amplified frequency. If so, one could perhaps understand why only some persons experience the hum and why the effect is strong at night time. White noise would be generated by body. White noise induces jumps between the states of the 2-state system with an average frequency f_K (Kramers frequency) which depends on the autocorrelation function of the white noise and the properties of the 2-state system [K105]. If the Kramers frequency satisfies $f_R = 2f$, where f is the frequency of the signal, a resonant amplification occurs. The dependence $f_K \propto exp(-\Delta V/D)$, where $\Delta V > 0$ is the height of the potential barrier separating the states of the 2-state system, implies and exponential sensitivity of f_K on 1/D, where D is the intensity of the white noise. Hence the failure of the em immune system could be due to the too intense white noise produced by the body of the victim or due a too low height of the potential barrier.

Are electronic systems involved with the hum?

The fact that the number of victims of hum has rapidly increased during the era of radio communications and computers and suggests that both radio noise and computers might be actively involved with the hum. Also ELF noise from electronic systems might be important if these systems generate dark ELF photons. Electronic instruments generate also frequencies in the range 40 - 80 Hz, in particular the 50 Hz frequency associated with the household electricity. Also submarine radars generate very strong ELF signals. The liquid crystal character of human body implies that besides weak sound signals also these ELF signals can contribute to the signal amplified by musculature. If these signals correspond to the lowest level of dark matter hierarchy, they should not have biological effects but whether this is the case is not all clear.

The strong coupling between magnetic flux tube structures associated the with computer networks and sensory canvases might be created by the magnetic reconnection process during night time when the shape of the flux tube structures changes. Also whole-daily use of a computer could generate magnetic mirror bridges between the computer and user's musculature and allow computer to feed fake control signals to muscles.

9.5.4 How TGD Approach Could Explain Taos Hum?

The original explanation for taos hum was as analog of microwave hearing.

- 1. According to the original explanation, taos hum could be understood in terms of this kind of Josephson radiation or more general radiation at microwave and also higher frequencies generated by living matter during night-time and possibly providing some organisms with an active "vision". The emission of negative energy dark photons could also make it possible for plants to suck metabolic energy from environment in the absence of solar radiation. This radiation would propagate along magnetic flux tube - ME pairs. Microwave hearing or its analog at higher frequencies would generate the experience of hearing. The question is what exactly happens in in microwave hearing or its analog.
- 2. The estimated wave length λ for sounds assignable to taos hum are in the range 4-8 meters: this estimate might comes from the correlation with the acoustic environment. Probably it comes simply from the formula $\lambda = c_s/f$, where $c_s = 3 \times 10^3$ m/s denotes sound velocity in air and f is the frequency 40-80 Hz assignable to the auditory experience on basis of neurophysiological correlates. This estimate must be taken with a big grain of salt.

If the primary signal is dark photon signal $f_l = 40 - 80$ Hz and if one takes the wavelength estimate seriously, one obtains the estimate $f_h = c/\lambda \simeq .05 - .1$ GHz. Unfortunately this frequency range is below the microwave frequencies varying in the range.3-300 GHz but scaling down of wavelength estimate by less than an order of magnitude would improve the situation. Thermal energy at room temperature corresponds roughly to 2.5×10^3 GHz so that the energies would be below the thermal energy at physiological temperatures. This cannot be however used as a serious objection against interpretation as microwave hearing since the wavelength estimate is based on the effective assumption that signal corresponds to 40-80 Hz ordinary sound wave.

The TGD based model for EEG [K48] is based on dark Josephson radiation generated by cell membrane Josephson junctions in the energy range of visible and UV light and covering a wide frequency range. The model explains bio-photons and EEG as manifestations of one and same basic phenomenon: dark photons and the recent observations support this identification [J48]. This motivates a more radical explanation of taos hum.

- 1. The auditory information is presumably coded to modulations of carrier wave with frequency f_h by frequency $f_l = 40 80$ Hz, which is in EEG range and could be assigned with the magnetic interaction energy of dark protons assignable to the opposite sides the cell membrane [J71] [L28]. Dark photon wave length would be of the order of the radius of Earth and the only reasonable explanation for the claimed correlation with the acoustics of the environment is that magnetic body provides a representation of biological body and environment as indeed proposed (magnetic sensory canvas hypothesis [K70]).
- 2. Since Josephson frequency characterizes the cell membrane frequency scale, one might expect that the dark photons signal has the same frequency. In this case the wave length would be of the order $\lambda = c/f \sim .1$ mm, size scale of large neuron rather than the naïve estimate $\lambda = 4 8$ meters.

- 3. The dark photon signal would be generated by an amplitude modulation of a carrier wave at Josephson frequency $f_h = 2eV \sim 5 \times 10^{12}$ Hz (for electronic Cooper pairs) by frequency $f_l = 40 - 80$ Hz. According to the conjecture proposed earlier [L28], this would generate dark photons with $\hbar_{eff} = f_h/f_l \sim 1.2 \times 10^{11}$ near the thermal threshold. It is highly interesting, Cyril Smith reports that the frequency ratio $f_h/f_l = 2 \times 10^{11}$ is involved with the transformation of high frequency signal to low frequency signal [J21].
- 4. This picture would conform with the original idea that left brain utilizes frequencies not smaller than Josephson frequency assignable to cell membrane and right brain hemisphere visible and UV frequencies. In TGD framework this difference would be due the fact that cell membrane can appear in two ground states [K59]. The state realized in right hemisphere near to the vacuum extremal with Josephson frequencies in visible and UV range and the state realized in left hemisphere far from vacuum extremals and Josephson frequencies derivable from membrane potential.

One should also understand how dark photon signal transforms to dark phonon signals and how this signal transforms to ordinary sound generating the taos hum experience. Two options can be considered: for the first option only dark photons are involved, for the second option both dark photons and phonons are involved.

- 1. Living body cell membrane is an electret and thus transforms electric signals to sound waves and vice versa. The minimum option is that signal propagates as dark photons and transforms to dark phonons of same energy at cell membrane level. One can consider also second possibility: dark photons continue to propagate along ME-flux tube pair parallel to the axonal membrane.
- 2. Dark phonons in the high frequency optical branch of the spectrum (/photons) would propagate as oscillations assignable to axonal membrane (/ME flux tube pair parallel to it) to ear. Dark phonons/photons would generate virtual auditory percept by transforming to ordinary phonons at ear.
- 3. Both the variants of the model could explain the basic findings about taos hum, in particular the fact that it creates a subjective experience without any objective counterpart.

One can ask why taos hum is not accompanied by its visual counterpart involving dark photons with visible photon energies. In fact, the persons suffering from taos hum occasionally report experiences of white light in the direction of sound. The mechanism could be essentially the same as for taos hum except that the right brain hemisphere is a better candidate for the receiver now if one takes TGD inspired view about cell membrane seriously.

9.6 Dark Photons In Biology And Neuroscience

In this section I want to add some details to the general vision about dark photons as deeper level behind bio-photons. What is certainly unusual that I will barely mention biochemistry. My knowledge about the complexities of biochemistry is not the reason for the neglect. The reason is that if hardware-software dichotomy in biology corresponds to the matter-dark matter dichotomy, the biochemistry separates neatly from the physics of dark matter for the software. It is a physical fact that dark matter dominates over ordinary matter in cosmic scales and is present everywhere so that it is not so surprising if dark matter would play a key role in biology. Recently the futile searches for WIMP (weakly interacting massive particle) with expected properties have forced particle physicists to ask whether dark matter could be much more than single WIMP, maybe a new phase of matter or even hierarchy phases as TGD suggests.

My basic defense for the notions of magnetic body and dark photons (also other dark particles) is that they follow from the basic TGD and allow to explain phenomena very difficult to understand in the standard biochemistry framework - consider only the correlation between EEG and bio-photons, coherence of bio-photons, and delayed luminescence.

9.6.1 General Vision

I have already explained the basic ideas about bio-photons as decay products of dark photons. In the following I try to develop a general vision about the role of dark photons in living matter.

- 1. Pulse patterns or temporal polarization patterns travelling along MEs are ideal for communications and control because of precise targeting, absence of dispersion and maximal possible signal velocity.
- 2. Resonance frequencies for dark photons could be an essential element in their interactions with biomatter. The most important of these interactions would be the generation of negentropic entanglement between new representations of mental images and already existing corresponding representations. For instance, for cyclotron Bose-Einstein condensates the magnetic fields at the ends of the sender and receiver must be equal in good accuracy. Password mechanism is suggestive: several resonance frequencies would define the letters of the password. Among other things this could lead to a selective remote activation of gene expression if dark photons represent codons of the genetic code [K149].

The vision of Hawkins about fundamental algorithm [L25] might find realization in TGD framework in terms of the basic anatomy of quantum jump in zero energy ontology (ZEO) [L29]. The basic idea is that conscious information processing consists of pairs formed by sensory perceptions (involving the recognition of the objects of the perceptive field) and by motor action. Sensory perception and motor action are related by time reversal and correspond to state function reductions at opposite boundaries of CD. These processes can combine to complex program like structures via generalization of lock and key mechanism in which fitting of the key to lock corresponds to recognition.

Lock and key mechanism is a well-known mechanism of bio-catalysis, and allows a far reaching generalization. Dark photons could provide a very general non-local realization of this mechanism.

- 1. Lock and key mechanism allows to imagine biochemical programs consisting from reactions proceeding in fixed order. The idea is same as in a familiar game of children. At each step player gets a key of a room containing a new key and the task is to find the room. After visiting many rooms the successful player eventually has the key to the room containing the treasure. In computer languages like LISP the same idea is realized: program is represented as a collection memory location containing two addresses: the address of memory location and the address of the next memory location. Associative memory recall could rely on the same mechanism.
- 2. Lock and key mechanism can be realized in several ways. The most concrete manner is as a chemical reaction in which reactants have complementary surface geometries fitting like lock and key. Keys could be replaced with passwords. The password could be represented as a collection of resonance frequencies. Also a pulse sequence or a more general temporal field pattern such as a sequence of magnetic fields with discrete valued strength and duration (Persinger has found that this kind of sequences are "physiologically effective" [J48, J50]. Temporal polarization patterns are also possible and are suggested by Gariaev's group [I54].

For frequency coding, a given step in the process would activate a collection of frequencies activating the next step of the program and magnetic flux tube connections along which signals propagate would allow to achieve highly selective activation.

3. The decomposition of quantum jump to state function reductions at opposite boundaries of CD explaining the sensory-motor dichotomy at the level of brain could be realized also at molecular level and define basically a pair of addresses/passwords. Sensory perception with recognition of the objects of the perceptive field would correspond to the fitting of the key to lock. The frequencies of future directed positive energy signals would serve as a password inducing a motor action generating a collection of frequencies of past directed negative energy signals serving as a password for the next step of reaction.

9.6.2 Dark Photons And Biology

A lot of experimental data about the role of bio-photons in biology exist [I64, I74, I112]. Coherence [I62] and closely related delayed luminescence [I38] are the basic poorly understood aspects of bio-photons. Already Gurwitsch demonstrated that mitogenetic radiation makes possible communication between cell cultures.

- 1. Passwords realized as frequency patterns could be at work also at the level of genome and rely on use of portions of DNA sequences as pairs of addresses. One could imagine a representation of DNA sequences in terms of frequency patterns of em fields.
- 2. Password mechanism realized in terms of frequencies for dark photons could allow interaction between remote genomes. One can imagine remote DNA replication, remote transcription and translation [K62]. If one accepts dark DNA [L3, K62] similar processes involving dark DNA and ordinary DNA can be imagined. I have discussed the role of dark DNA in making possible kind of R&D department allowing to test new variants of genes in the virtual world of dark DNA, RNA, tRNA and dark amino-acids. Peter Gariaev's findings suggest the possibility of remote DNA replication and remote activation of gene expression [K149].
- 3. The mechanism for the generation of sensory -, memory -, and cognitive representations as negentropically entangled zero energy states getting new tensor factors during quantum jump sequence is extremely general. Same can be said about the interaction free measurement as a mechanism for nondestructive reading of these representations. This suggests that they are realized already at the biomolecular level so that also conscious intelligence is present already at nanolevel. What we call molecular machines would be conscious entities and swarm intelligence as a mechanistic algorithm would be replaced by self-organization of conscious entities able to co-operate thanks to the presence of collective levels of consciousness made possible by the magnetic bodies and flux tube reconnections generating larger quantum coherent structures.
- 4. One can imagine new mechanisms of metabolism based on dark photons. Dark photons could take the role of sunlight and provide energy for electrons in electron transport cycle appearing in both cell respiration and photosynthesis. The effect of visible laser light on skin might involve this kind of mechanism. Negative energy dark photons emitted by electrons would make possible remote metabolism (quantum credit card mechanism).
- 5. The possibility to transform ordinary photons to dark photons is what one should understand. The findings of Peter Gariaev [I54] can be explained in TGD framework if DNA transforms laser photons to dark photons with frequencies of radio waves extending at least to kHz. Somehow DNA is able to induce the phase transition changing the value of \hbar_{eff} : amplitude modulation by radiofrequencies is a good candidate for mechanism in the case that the frequency ratio equals to integer valued ratio \hbar_{eff}/\hbar .

9.6.3 Dark Photons And Brain

The role of dark photons in imagination and for memories has been already discussed. Dark photons could also have a role in vision.

1. In TGD inspired theory of consciousness sensory qualia are assigned with sensory receptor. These primary sensory mental images are negentropically entangled with the mental images at brain and magnetic body (decomposition of perceptive field to objects). Qualia would represent the colors of perceptive map. This assumption can be justified by very general arguments such as general coordinate invariance implying holography but is not absolutely necessary. Mental images at the magnetic body could be also involved with the entanglement sequence giving higher abstractions about the sensory input.

The basic objection (phantom leg) can be circumvented 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. The pain could be also real but erroneously assigned with the non-existing leg.

- 2. The notion of sensory window is almost two decades old notion [K91]. In its recent version dark photons propagate along MEs associated with magnetic flux tubes parallel to neural pathways, perhaps both from and to sensory organs. Experimental evidence for the propagation of bio-photons signal between nerve ends [J103] provide support for this idea. Stimulation of other end by light induces bio-photon emission at the other end. What would happen that dark photons are generated a the first end and propagate to other end along MEs and decay to ordinary photons.
- 3. Seeing without the brain or more precisely without neuronal connections to brain is now known to be possible. Does this mean that dark photons mediate information to brain or that retina plus spine "see" and that the geometric aspects of vision are realized also at the level of retina?
- 4. Dark photons from magnetic body or brain or both to retina transforming there to ordinary photons could provide feedback allowing to transform visual input to stardardized visual mental images. The proposed mechanism would require that retina produces seeds for induced transformation to ordinary photons. This is a testable prediction: does retina generate light? Same mechanism could of course generate photons at the visual cortex so that visual mental images could be generated also there. Dissipation would be also now unvoidable aspect of process and one of the basic functions of metabolism would be regeneration of dark photons.

There is a phenomenon called visual prosthesis referred also to as bionic eye (http://tinyurl.com/9kasp3q) providing support for the idea that also neurons can see. Bionic eye can provide the effect sense of vision in a situation when there is degenerative disease of photoreceptors and even for people born blind. Of course, the visual experience need not be same as for ordinary vision: it is possible to "see" geometric information about environment using only tactile sense. In any case, the sensation of vision is at neuronal level unless some functions of retina are still active: I do not know whether this must be the case or not.

The basic visual sensation is phosphene (http://tinyurl.com/l8vpbu), kind of diffuse light spot. If phosphenes are basic building bricks of also ordinary vision, the hypothesis that primary sensory organs are carriers of qualia can make sense only if prosthete vision is fundamentally different from ordinary vision. This is possible. Neurons can "see" in TGD framework (I have talked about neuronal windows): at this level vision relies on the reception biophotons travelling along magnetic flux tubes assignable to neuronal pathways. Retinal receptors would be specialised on vision and much more effective than neurons, which would detect just the presence of light.

5. This picture would make possible similar representations also for the other sensory modalities. For instance, people learn to "see" via tactile sensation and also by hearing.

Correlations between bio-photons, EEG, and neural activity

The recent experimental understanding about correlations between emission of bio-photons and neural activity of the brain is thoroughly discussed in [J51].

1. In vivo experiments of Kobayashi et al [J40] demonstrate that the spontaneous ultraweak photon emission from a rat brain correlates with cerebral energy metabolism, EEG activity, cerebral blood flow and oxidative stress. Van Wijk et al [J60] have demostrated significant correlations between fluctuations of alpha wave portion of EEG and bio-photon emission. It has been also demonstrated that neuronal axons can conduct photon signals [J103]. Thus there is a lot of evidence that bio-photons or something behind them are real and could serve communication purposes. Bischof has proposed that visual consciousness is a property of bio-photon field itself [J83]: this kind of conjecture is problematic philosophically and a weaker hypothesis about the correlation with visual consciousness and/or visual imagination looks more natural.

2. The article takes as granted that bio-photons are produced by biochemical processes related to reactive oxygen and nitrogen species (ROS and RNS). There is a strong correlation with oxidative metabolism of mitochondria. If f bio-photons are not fundamental entities, this correlation does not mean that these processes would directly produce bio-photons.

One can however invent several objections against this mechanism.

- (a) Too short de-coherence time is the basic objection Tegmark's estimate for the decoherence time of bio-photons is $\tau \sim 10^{-13}$ seconds. The estimate is rough and gives coherence time increasing with temperature but certainly the lacking 10 orders of magnitude are a real problem and would require that generation of ROSs and RNSs is a highly coordinated mechanism. There are indeed indications that free radicals and their derivatives are necessary for synaptic processes and ordinary brain functions. If magnetic body controls metabolism the underlying quantum coherence could imply the required high spatial and temporal coordination.
- (b) Delayed luminescence is difficult to understand if only biochemistry is behind biophotons.
- (c) A further problem is the extreme weakness of bio-photon flux at least in the vicinity of organism where the measurements are made. The argument of authors is that the strong absorption of bio-photons in living matter is the reason for this.

Despite these difficulties the authors suggest that bio-photons define a new kind of fast signalling accompanying electric signalling (nerve pulses and waves propagating along axonal membranes) and consider a quantum model for the interaction of bio-photons with microtubules. As a matter of fact, the idea about microtubules as quantum antennae represents one of the first applications of the notion of "massless extremal" (ME) to biology in [K91].

I have already described the basic deviations of TGD based model from this picture. Dark photons relevant to biology make themselves visible by transforming to bio-photons by energy conserving manner: this gives rise to frequency pairs (f_h, f_l) with $f_h/f_l = \hbar_{eff}/\hbar = n$. The other member of the pair would reveal itself classically as low frequency classical radiation and second pair as higher frequency photon. The pairing of EEG with bio-photons could be understood in terms of this pairing. The findings of Cyril Smith [J21] would have interpretation of this pairing allowing also other than EEG frequencies as dark photon frequencies. Also the findings of Peter Gariaev [I54] suggest that also radio wave frequencies can appear as dark photon frequencies.

According to [J51] the evidence for the correlation between neural electrical activity of neurons and bio-photon emissions is however poor. Situation might improve in future but one can ask whether it could be possible to understand the poor correlation.

- 1. If the transformation of dark photons at EEG frequencies to ordinary photons gives rise to bio-photons, it might be possible to understand the poor correlation. Neuronal activity would modulate membrane potential and the therefore the frequency $f_J = eV/h_{eff}$ of Josephson radiation but not Josephson current determining its magnitude. Note that f_J can be also outside the EEG range and TGD suggests a hierarchy of scaled up variants of EEG.
- 2. Neural events would have time scale of order milliseconds much shorter than the time scale of EEG so that the frequency modulation caused by them would not be visible in the time scale T_{EEG} of EEG frequencies considered. Only the slow modulations of membrane potential in time scales longer than T_{EEG} would be visible as a slow variation of corresponding biophoton energy. The testable prediction is that the time variation of the frequency spectrum of bio-photons directly reflects that of EEG spectrum.

Biophotons and vision

Bischof [J83] was probably the first one to propose that bio-photons might relate directly to vision. The following list of articles by Bokkon *et al* illustrates the development of ideas about the connection between bio-photons and vision. I have included a comparison with TGD based views, which have developed during last two decades and are discussed in chapters of various online books [K91, K70, K98].

• Phosphene phenomenon: a new concept [J73].

It is proposed that the visual sensation of phosphenes (induced by mechanical, electrical, magnetic situli, ionizing radiation, etc..) is due to bio-photon emission inside neurons. Also an interference model concerning the mechanism of interaction between living organisms and electromagnetic fields is proposed. Authors suggests that the biological nonlinearly polarizable double layer allows destructive interference of incoming and reflected waves outside the double layer. As a consequence, in the inside constructive interference would take place at the same time. The proposal is that the interference patterns may play an important role in biological self organization and in biological functions.

The authors investigate the boundary conditions necessary for explaining these non-linear optical effects in terms of the phase conjugation, and claim that there are solutions of the Maxwell equations which satisfy destructive interference of bio-photons. Necessary provisions are nonlinearly polarizable optically active double layers of distances which are small compared to the wavelength of light. In addition, they have to be able to move into the nodal planes of the impinging waves within a small time interval compared to the coherence time. The claim is that the conditions are likely fulfilled in the optically dense, but ordered and optically excited, highly polarizable living matter.

In TGD framework phosphenes could result via a transformation of dark photons to biophotons. The propose interference model is needed to channel the electromagnetic fields inside cells and axons. In TGD framework the nonlinear modification of Maxwell's equations resulting from the fact that gauge potentials as primary dynamical variables are replaced with embedding space coordinates, implies topological field quantization manifesting structures like massless extremals (MEs), magnetic flux quanta (sheets and tubes) and electric flux quanta realized as space-time quanta. Hence precisely targeted beams of dark photons become possible.

• Picture representation during REM dreams: a redox molecular hypothesis [J19].

The proposal is that the visible photons in retina are converted to neural signals, which in V1 are are converted into synchronized bio-photon signals inside the neutrons by neurocellular radical reactions in retinotopically organized V1 mitochondrial CCO-rich (CCO is a shorthand for cytochrome oxidase) visual areas.

The TGD counterpart for this would be the conversion of the neural signals to dark photon signals to the magnetic body with ROS and RNS reactions inducing a small leakage to biophotons. One can also imagine that dark photons are generated at regina and travel along visual pathway so that the communications to magnetic body would be much faster. The feedback as dark photons from magnetic body to brain to retina would generate virtual visual input which in wake-up state would be compared with the actual input. During REM dreams only the virtual sensory input would be present. In retina dark photon input would generate bio-photon emission and this kind of emission is observed [J59]. One can wonder whether the dark photon emission from retina reflected from target could give rise to a "lamp" making possible "active" seeing under some circumstances.

Cytochrome oxidase (CCO) enzyme (see http://tinyurl.com/6ep3ob) is integral membrane protein permanently associated with the cell membrane and coded by mitochondrial DNA, and thus directly related to energy metabolism catalysing the reduction of oxygen to water in respiration and therefore something very primordial biologically. In TGD inspired model CCO would be needed for generating metabolic energy needed to generate dark photons. This would suggest that CCO rich regions are present also in other sensory areas. An interesting question is whether CCO rich regions are present both in left and right hemisphere. There is evidence that bio-photons are emitted considerably only in right hemisphere [J48]. Could this mean that the energy range for dark photons from left hemisphere is different or that dark phonons/biophonons effectively replace dark photons/bio-photons?

• Visual perception and imagery: a new molecular hypothesis [J31].

The authors describe the basic hypothesis that neural signals from retina generate synchronized bio-photon signals by radical and non-radical processes in retinotopically organized visual areas and that these bio-photon signals provide intrinsic pictures in retinotopically organized mitochondria-rich visual areas.

It is also proposed that long term visual memory corresponds to epigenetic information regulated by free radicals and redox processes. There is indeed evidence that reactive oxygen species and related haem pathway components as possible epigenetic modifiers in neurobehavioural pathology [J66].

The TGD counterpart of this hypothesis is that dark photons generate representations of visual field at brain and possibly also at various layers of magnetic body with different degrees of abstraction. For dark EEG photons the layers would have size of order Earth radius suggesting a connection with Schumann resonance and magnetosphere as a higher level in the predicted self hierarchy.

Epigenetic modifications and changes of synaptic connections would correspond in TGD framework to behavioral changes, not genuine conscious memories. The idea that ROS and RNS could perform this "carving" process analogous to the modification of computer hardware (now represented by biochemistry), is attractive. In TGD Universe genuine declarative memories would be however realized in terms of representations based on bit representations (see Fig. http://tgdtheory.fi/appfigures/cat.jpg or Fig. ?? in the appendix of this book).

• Estimation of the number of bio-photons involved in the visual perception of a single-object image: bio-photon intensity can be considerably higher inside cells than outside [J31].

Authors consider two objections against biological role of bio-photons. First, bio-photons are a mere byproduct of cellular metabolism. Secondly, the extreme weakness of bio-photon flux does not support the idea that they might have biological significance. Authors however argue that bio-photon production is a controlled process and among other things gives rise to the above mentioned synaptic and epigenetic modifications. Authors also argue that the density of bio-photons inside cells is considerably higher than outside and consider a mechanism in which em fields are confined inside bilayered structures.

In TGD framework bio-photons are replaced by dark photons propagating along MEs. Their intensity can be much higher and bio-photons would represent a small leakage resulting from the transformation of dark photons to bio-photons. Unfortunately one cannot say much about the rate of this process: p-adic length scale hypothesis however probably fixes it to be inversely proportional to the secondary p-adic time scale (.1 seconds for M_{127} characterising electron) and hierarchy of Planck constants suggests that the rate behaves like \hbar/\hbar_{eff} . The strong correlation with metabolism can be understood since the generation of dark photons requires metabolic energy. An interesting question is what happens at other sensory areas: are CCO rich regions present also there?

• Visible light induced ocular delayed bioluminescence as a possible origin of negative after image [J32].

The motivation of the article is the experimental proof of the existence of spontaneous ultraweak photon emission and visible light induced delayed ultraweak photon emission from in vitro freshly isolated rat's whole eye, lens, vitreous humor and retina [J59]. Authors propose that the photobiophysical source of negative afterimage can also occur within the eye by delayed bioluminescent photons. When one stares at a colored (or white) image for few seconds, external photons can induce excited electronic states within different parts of the eye that is followed by a delayed re-emission of absorbed photons for several seconds. Finally, these reemitted photons can be absorbed by non-bleached photoreceptors that produce a negative after image.

In TGD framework one could understand the emission of bio-photons from retina as a leakage phenomenon. After images and delayed luminescence in general could be seen as a kind of echo resulting when dark photons travel to brain, maybe also magnetic body and return back after exciting laser like system which returns to it ground state by secondary emission. After images perhaps assignable to dark photons could give build up copies of memory representations. This could also apply to dark phonons: examples about this would be a repetition of single world or simple piece of music occurring during wake-up state and in sleep mentation.

A virtual sensory input propagating to the sensory organs would allow to check whether it is consistent with the actual sensory input. The generation of the feedback signal takes some time expected to be much shorter than that for a typical neuronal activity.

Since the signals would propagate with light velocity, the virtual sensory input could travel practically instantaneously from the brain to sensory organs and possibly also vice versa. Libet's experiments on passive aspects of consciousness [J42] in fact demonstrate a time delay which is fraction of second having interpretation in terms of time to propagate to a layer of magnetic body of size scale of Earth and back: these delays are consistent with the fact that the chronon of sensory experience is about.1 seconds. The propagation of photon signals in both directions would make possible construction of sensory representation in time scale much shorter than that of neural activity.

As special case this mechanism would explain after images. After images would be sensory echoes resulting when the sensory signal travels to magnetic body and back to sensory organs, maybe several times. The time scale for negative after images is seconds and in principle this allows to get some idea about the slow time scales involved with the process and maybe also about the size scales of largest layers of the magnetic body involved.

Biophotons and intelligence

It is gradually becoming clear that bio-photons have a role in brain function. An interesting claim is that the biophoton spectrum is shifted towards infrared as the intelligence of the species develops [I70](see http://tinyurl.com/ycor8hs3). The idea is that biophotons are involved with the communications between parts of brain and biophotons with lower frequencies are favored: one reason could be metabolic economy since biophotons have energies in visible and UV range mostly and in humans the extends to near infrared. The observation is that glutamate-induced biophotonic activities and transmission in brain slices represent a spectral redshift feature from animals to humans.

Could TGD based model for biophotons as decay products of dark cyclotron photons help to understand this? In TGD framework dark photons would be involved with communications of biological body with personal magnetic body (MB) [L28, K20]. Bio-photons would result from dark cyclotron photons in energy conserving transformation to ordinary photons reducing the value of Planck constant $h_{eff} = n \times h$ to its ordinary value h. Dark matter as phase of ordinary matter with non-standard value of Planck constant

$$h_{eff} = n \times h = h_{gr} = \frac{GMm}{2\pi v_0}$$

proposed to be generated at quantum criticality [?]. Gravitational Planck constant h_{gr} was originally introduced by Nottale [E1]. In this formula M is some mass, say that of black hole or astrophysical object, m is much smaller mass, say that of elementary particle, and v_0 is velocity parameter, which is assumed to be in constant ratio to the spinning velocity of M in the model for quantum biology explaining biophotons as decay products of dark cyclotron photons.

Both dark cyclotron photons from MB to brain and analogs of Josephson photons from cell membranes to MB would be involved in biology. When dark photons transform to ordinary photons they can induce molecular transitions. MB would control biomatter by inducing these molecular transitions. This explains the range of biophoton energies. Also EEG would consist of dark photons in this energy range but frequencies in EEG range and wavelengths of astrophysical size (7.8 Hz corresponds to circumference of Earth).

Dark cyclotron photons have cyclotron energy

$$h_{eff} \times \frac{eB_{end}}{m} = \frac{GM}{v_0} \times eB_{end}$$

independent of the mass of charged particle mass, which is essential for the universality of biophoton spectrum. The value B_{end} of the "endogenous" magnetic field introduced by Blackman should vary by say two orders of magnitude to explain the range of biophoton energies. The value of h_{eff} should be rather high.

The redshift of biophoton energy spectrum for humans as compared to lower animals could mean that the spectrum for the values of B_{end} extends to lower values. Cyclotron periods would be also longer at lower end for the spectrum. Could the higher intelligence could be achieved by better metabolic energy economy? Or could the presence of flux tubes with lower value of B_{end} extend the spectrum of biophoton energies and bring in molecules with lower transitions energies (down to near infrared)? It should be possible to identify the molecules in question. They should be involved with the "glutamate-induced biophotonic activities". The communications between brain slices could be also indirect: first sensory signal to MB is sent and response comes as control signal to other part of brain.

The value of B_{end} in Blackman's experiments (I have identified it as lower end for the spectrum of the values of B_{end}) for vertebrates was 2/5 of Earth's magnetic field B_E with nominal value of .5 Gauss. Why 2/5 rather than 1? Could this reflect that gradual reduction of B_{end} from B_E during evolution? Should one repeat the experiments of Blackman and other pioneers for non-vertebrates to find whether B_E is higher for them?

9.6.4 Dark Photons, Meditative States, And Qigong Practices

Various experiments demonstrate that meditation tends to reduce bio-photon emission [J111, J20]. The interpretation would be that for some reason meditation reduces the leakage of large \hbar photons to ordinary ones. How meditation could help to achieve this reduction?

If the generation of ROS generates bio-photons by the proposed mechanism with the ordinary photon generated in ROS serving as a seed inducing the transformation of dark photons of same energy to bio-photons then reduction ROS would explain the correlation. The life style of meditator might explain why the generation of ROS is reduced. If dark photons are involved with nondestructive reading of memories and future plans (time reversed memories), and if the absorption of dark photons by laser like systems followed by a return to ground state leads to an emission of also ordinary photons then cognitive processes would generate bio-photons. In meditative practices the basic goal is to calm mind by getting rid of thoughts so that this mechanism would not produce photons anymore.

The effects of Qigong practices on bio-photon emission has been also studied. Examples are changes of bio-photon emission and temperature of human hand during Qigong [J47], the effects of mental concentration on bio-photon emission [J37], temperature and bio-photon changes of the middle finger during Qigong and light imagery tasks [J33], and comparison of bioenergy and physiological markers in qigong and acupuncture research has been carried out [J43].

Quite generally, the hands of qi healer are expected to emit bio-photons. If Qi healer generates a flux of dark photons, some fraction of them dissipates to bio-photons, so that an increase of bio-photons could be the outcome.

9.7 Dark Photons And Remote Mental Interactions

Remote mental interactions are the same interactions that relate magnetic body and biological body. Now biological body is not the "personal one" but that of target and can be also inanimate in which case the presence of codes are not expected.

- 1. Flux tubes serve as correlates of attention. Attention would therefore be always involved with remote mental interactions also those between various layers magnetic body and parts of biological body manifesting themselves in the biology of TGD Universe. Dark photons propagating along ME-flux tube pair serve as correlates of communication and control. "Motor actions" of magnetic body serve as tools of bio-control too. Also the reading of memory representations would involved dark photons and could therefore be involved with telepathy as mind reading.
- 2. Dark photons would accompany various remote mental interactions and the unavoidable leakage as bio-photons could be a signature of these interactions. For instance, healer generates low frequency dark photons along flux tubes creating the connection to the patient and part

of these photons leak out in the process. Dark photons are expected to leak from the hands of healer as bio-photons.

- 3. Could simultaneous changes in bio-photon emissions from healer and healee take place and be also detected? Identical values of f_l and f_h for healer and healee would serve as as a signature. In principle testable aspect of darkness is the integer aluedness of $\hbar_{eff}/\hbar = f_h/f_l$. From quantum coherence criterion the distance roughly $L \leq c/f_l$ allows to guess upper bound for the value of f_l . The additional signature would be the identical temporal patterns of dark photons correlation functions at both ends. This would be the analog of long range temporal correlations in delayed luminescence.
- 4. Dark photons could be seen as universal mechanism of remote viewing. Do various sensory modalities involve separate frequency bands f_h or is the frequency band determined solely by distance? This question relevant also for brain. Second relevant question is the role of magnetic bodies. The model for the findings of Willian Tiller about intentional imprinting of electric devices [J110, J105, J106] requires that magnetic bodies serve as relay stations in this process. Both healers and healee's magnetic bodies and even those assignable to levels of collective consciousness could be involved (healing by prayer).

Acknowledgements: I want to express my gratitude for Lian Sidorov for generously providing abstracts and other material related to bio-photons as well as for inspiring discussions.
Chapter 10

Dark photons from transitions of dark valence electrons as origin of bio-photons, and their interaction with carcinogens

10.1 Introduction

The possible role of bio-photons in living matter is becoming gradually accepted by biologists and neuroscientists. It seems that the intensity of bio-photon emission increases in sick organisms and bio-photons are used as a diagnostic tool. Fritz Popp (see http://tinyurl.com/y7assha7) started his work with bio-photons with some observations about the interaction of UV light with carcinogens [I75] (see http://tinyurl.com/y76a9fo4). Veljckovic (http://tinyurl.com/yatedje8) has also published results suggesting correlations between carcinogenity and the absorption spectrum of photons in UV (ultraviolet).

I have proposed that bio-photons emerge as ordinary photons from what I call dark photons, which differ from ordinary photons in that they have non-standard value $h_{eff} = nh_0$ of Planck constant [K20, L28]. Also other particles - electrons, protons, ions,..., can be dark in this sense.

One of the mysteries of biology, which mere biochemistry cannot explain, is that living systems behave coherently in macroscopic scales. The TGD explanation for this is that dark particles forming Bose-Einstein condensates (BECs) and super-conducting phases at magnetic flux tubes of what I call magnetic body possess macroscopic quantum coherence due to the large value of h_{eff} . This quantum coherence would force the coherent behavior of living matter. I have already earlier developed rather concrete models for bio-photons [K20, L28] on basis of this assumption.

In the sequel I will discuss bio-photons from a new perspective by starting from bio-photon emission as a signature of a morbid condition of organism. The hypothesis is that in sick organism dark photons tend to transform to bio-photons in absence of metabolic feed increasing the value of h_{eff} . Hence BECs of dark photons and also of other dark particles decay and this leads to a loss of quantum coherence.

A further hypothesis is that at least a considerable part of bio-photons emerge in the transformations of dark photons emitted in the transitions of lonely dark valence electron of any atom able to have such. Since dark electron has a scaled up orbital radius, it sees the rest of atom as a unit charge and its spectrum is in good approximation hydrogen spectrum. Therefore the corresponding part of the spectrum of bio-photons would be universal in accordance with quantum criticality.

This picture allows to develop some ideas about quantum mechanisms behind cancer in TGD framework.

10.1.1Some basic notions related to carcinogens

Before continuation it is good to clarify some basic notions. Toxins are poisonous substances created in metabolism. Carcinogens (http://tinyurl.com/ybphtjqg) are substances causing cancer, which often cause damage to DNA and induce mutations (mutagenicity).

Free radicals (see http://tinyurl.com/y9bxoqjz) provide a basic example about carcinogens. They have one un-paired valence electron and are therefore very reactive. The un-paired electron has a strong tendency to pair with an electron and steals it from some molecule. The molecule providing the electron is said to oxidize and free radical to act as oxidant. The outcome is a reaction cascade in which carcinogen receives electron but electron donor becomes highly reactive. Anti-oxidants stop the reaction cascade by getting oxidized to rather stable molecules (http://tinyurl.com/omb7kc9 and http://tinyurl.com/ydeloxcn).

Benzo[a]pyrene (BAP) $C_{20}H_{12}$ (see http://tinyurl.com/y8etnmwb) is one example of carcinogen. It contains several carcinogenic rings and is formed as a product of incomplete burning and reacts with powerful oxidizers. As such BAP is not free radical but its derivatives BAP^{\pm} obtained by one-electron reduction or oxidation are such (see http://tinyurl.com/yb7am8tk).

There are also carcinogens such as bentzene, which as such is not dangerous. What happens is that to the carbon at the ends of bentzene's double bond binds single oxygen atom and so called epoxy bond is formed. This molecule penetrates to the DNA chain and causes damage. Perhaps the fact that DNA nucleotide also contains aromatic 6-rings relates to this.

The emission of bio-photons (see http://tinyurl.com/ol39rqx) increases if carcinogens such as oxidants are present. The idea is that bio-photons could be relevant concerning the understanding of the problem. It has been proposed that bio-photons could be created when anti-oxidants interact with molecules generating triplet states (spin 1) which decay by photon emission. The photons generated in this way would have discrete spectrum whereas bio-photons seem to have continuous and rather featureless spectrum. Therefore this model must be taken with caution.

It could be that the origin of bio-photons is not chemical. If so, carcinogens would not produce bio-photons in ordinary atomic or molecular transitions. They could be however induce generation of bio-photons indirectly. The understanding of bio-photons might help to understand the mechanisms between carcinogenic activity. I have discussed bio-photons from TGD view in [K20, L28].

Some basic notions of TGD inspired quantum biology 10.1.2

In the sequel I try to develop a necessarily speculative picture about carcinogen action on basis of TGD based quantum about biology [K99, K129]. The goal is to develop the general theory by developing a concrete model for a problem.

Magnetic flux tube and field body/magnetic body are basic notions of TGD implied by the modification of Maxwellian electrodynamics [K99, K70, K120]. 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/magnetic body as a magnetic 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 [L52] and the model for color vision [L84] 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 [B15] [L51]. Flux tubes would also 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 [L63, L86]. The dynamics of mental images would correspond to that for the flux tube networks.

10.1.3 The proposed model briefly

In the sequel the basic hypothesis will be that dark photons emerging from the transitions of dark valence electrons of any atom possessing lonely unpaired valence electron could give rise to part of bio-photons in they decays to ordinary photons. The hypothesis is developed by considering a TGD based model for a finding, which served as a starting point of the work of Popp (see http://tinyurl.com/y76a9fo4): the irradiation of carcinogens with light at wavelength of 380 nm generates radiation with wavelength 218 nm so that the energy of the photon increases in the interaction. Also the findings of Veljkovic about the absorption spectrum of carcinogens (http://tinyurl.com/yatedje8) have considerably helped in the development of the model.

The outcome is a proposal for dark transitions explaining the findings of Popp and Veljkovic. The spectrum of dark photons also suggests a possible identification of metabolic energy quantum of .5 eV and of the Coulomb energy assignable to the cell membrane potential. The possible contribution to the spectrum of bio-photons is considered, and it is found that spectrum differs from a smooth spectrum since the ionization energies for dark valence electrons depending on the value of h_{eff} as $1/h_{eff}^2$ serve as accumulation points for the spectral lines. Also the possible connections with TGD based models of color vision and of music harmony (see [L84, L32, L92]) are briefly discussed.

10.2 About the modelling of the basic findings of Popp and Veljkovic

The popular article about starting point of Popp's research work (see http://tinyurl.com/ y76a9fo4) tells that one can assign to carcinogens such as benzo[a]pyrene (polycyclic aromatic compound - a wave length $\lambda_i = 380$ nm. Carcinogen absorbs this wavelength and radiates photons with a shorter wavelength $\lambda_f = 218$ nm. In the following I try to understand what could happen in this process. I also consider the observations of Veljkovic [I133] and their relationship to the findings of Popp.

10.2.1 General TGD picture

The zeroth order iterate for TGD interpretation of the action of free radicals would be following. Free radicals lead to the destruction of dark phases with non-standard value of h_{eff} . These phases include Bose-Einstein condensates of various kinds and super-conducting phases. The process leads to an emission of dark photons which transform to ordinary photons identified as bio-photons in the phase transition $h_{eff} \rightarrow h$. For instance, this happens as vegetable ageing and bio-photon emission is indeed used as a tool to determine the age of vegetable.

How the stealing of electrons by free radical electrons could induce the negative biological effects?

1. Quantum coherence is essential for what it is to be living matter. Bio-system is full of different kinds of Bose-Einstein condensates (BECs) and superconducting phases [K100, K101]. Electronic super-conductivity is one of the most important examples. There are also cyclotron BECs for proton Cooper pairs and biologically important bosonic ions or of the Cooper pairs of fermionic ions such as Ca²⁺, Mg²⁺, Fe²⁺, Na⁺, K⁺, Cl⁻. The value of h_{eff}/h_0 for these BECs would be rather large being in the range $10^{12} - 10^{15}$. In this case h_{eff} can be identified as gravitational Planck constant h_{gr} assignable to the magnetic flux tubes mediating gravitational interaction [K117, K93, K95, ?] [L81]. This would guarantee that cyclotron energies proportional to h_{eff} in endogenous magnetic field $B_{end} = 2/5B_E$, where $B_E = .5$ Gauss is the magnetic field of Earth, are above thermal energy at physiological temperature so that dark cyclotron photons can have biological effects.

2. Hydrogen bonds are central for the chemistry of water and living matter. The atoms able to form hydrogen bonds (O,N,...) possess so called lonely electron pair meaning that neither electron belongs to a valence bond.

A possible TGD picture would be following. Hydrogen bond can be assigned with magnetic flux tube at which there is a delocalized proton, which can be also dark $(h_{eff} = n \times h_0 > h)$. The lonely electron pair forms a Cooper pair. The electrons of the Cooper pair are at the members of a flux tube pair. Flux tubes are parallel but magnetic fluxes are in opposite directions if Cooper pair has spin 0. Spin 1 would correspond to fluxes in the same direction. Hydrogen bonds and their scaled up (by $h_{eff}/h_0 = n$) dark versions would correspond to flux tube pairs.

The physics of water is plagued by anomalies. It has become recently clear that water must involve two phases. In TGD framework [L89] water would have dark fraction involving dark flux tubes carrying dark protons and electrons and this would allow to understand the anomalies. Intriguingly, the anomalies are strongest at physiological temperature.

3. The basic mechanism behind cancer could be following. Free radicals steal electrons and this leads to the destruction of quantum coherence as electronic Cooper pairs are destroyed and super-conductivity is lost. $h_{eff}/h_0 = n$ is reduced. This number can be regarded as a kind of IQ assignable to flux tube and one could speak about intelligence characterizing flux tube network. More precise interpretation is that the higher the value of h_{eff}/h_0 is, the higher the ability to generate conscious information is. System can also destroy information: in quantum ethics this means doing something evil!

Remark: A little additional comment, which might irritate physicalist. TGD inspired theory of consciousness [L77] suggests strongly the emergence of ethics at fundamental quantum level. Quantum ethics is simple and universal: doing good is to increase the conscious information of the Universe about itself. This conforms with the fact that doing evil forces secrecy and the Universe loses conscious information.

The networks formed by molecules connected by flux tubes serving as correlates for quantum entanglement decay as the Planck constant at flux tubes becomes normal and they reconnect to form short loops. The community of molecules/cells decomposes into individuals, whose basic purpose degenerates to replication. Cancer is the outcome.

- 4. The general picture could be that the value of h_{eff} :n is reduced due to the transitions $h_{eff,i} \rightarrow h_{eff,f} < h_{eff,i}$ induced by the free radical stealing electrons. It is quite possible that the valence electron of free radical is dark.
- 5. What could happen in the stealing of electron? The valence electron of carcinogen (say free radical) must be dark in order that it gets on the flux tube at which Cooper pair is. Electron could be kind of Troyan horse getting to the flux tube associated with the hydrogen bond and then would react with Cooper pair splitting it and the resulting pair of electrons would consist of ordinary ordinary electrons.

10.2.2 Basic observation

The starting point is a reaction, in which the irradiation of carcinogen produces radiation with higher photon energy. In the example consider the incoming photon has wavelength $\lambda_i = 380$ nm and energy a $E_i = 3.27$ eV, which is just at the border 3.26 eV of violet and ultraviolet. The outgoing wavelength is $\lambda_f = 218$ n, and the corresponding energy is $E_f = 5.69$ eV and therefore in UV. As such this photon does not cause harm to say DNA.

I understand this kind of reaction is rather generally occurring for carcinogens and toxins. This suggests that the action of toxins and carcinogens is universal and relies on mechanism not depending strong the molecule considered. Understanding this on basis of standard chemistry is challenging.

I also understand that the energy 3.27 eV is special in biology and might relate to the communication between cells and that carcinogenic action somehow spoils this communications. It is also known that the emission of bio-photons in presence of carcinogen increases. If these

photons are actually dark photons then dark photon BE condensate could be lost in the process and lead to a reduction of quantum coherence.

10.2.3 Possible detailed models for the observations of Popp

TGD based model for bio-catalysis assumes that catalyst and substrate are connected by flux tube or flux tube pair and that one can associate to this object a resonance frequency. One can ask whether carcinogen could act like catalyst.

Dark valence electrons behave like electrons of dark hydrogen atom

What could happen in the above process?

1. What looks strange is that the energy of final state photon is higher than initial state photon. naïvely one would expect just the opposite.

Could it be that the atom in the initial state is - in some sense not necessarily possible in standard atomic physics - in an excited state and the absorption of incoming photons makes it even more excited state. In the final state atoms returns to ground state in some sense not necessary that of standard atomic physics. This is like jumping upwards from balcony and dropping down.

- 2. Electronic excitation energies for atoms must be in question. The energy scale is however too small for the transitions of hydrogen atom and even more so for those of heavier atoms. The ground state binding energy of hydrogen atom is 13.6 eV. For other atoms the energies of inner electrons are proportional Z_{eff}^2 , where Z_{eff} is the effective charge of nucleus, which is screened by electrons in full shells so that Z_{eff} is considerably reduced for valence electrons.
- 3. How could one understand the universality? Suppose that an unpaired valence electron is in question and that it is dark. For any atom dark valence electron has orbital radius scaled up by factor $(h_{eff}/h)^2 = (n/6)^2$ so that dark valence electron sees effective nuclear charge $Z_{eff}=1$ and behaves like an electron of hydrogen atoms apart from small corrections coming from the mass of the nucleus! In the sequel I will call any atom with one dark valence electron (or possibly even several of them) dark hydrogen atom.
- 4. One can therefore assume that one has effectively transitions of dark electron of hydrogen with $h_{eff}/h = n/6 > 1$. The binding energy scale would be reduced by a factor $(h/h_{eff})^2 = (n_0/n)^2 = (6/n)^2$.

Remark: The assumption $h = n_0 \times h_0$ raises of course bewilderment. It is however quite possible that h is not the minimal value of h_{eff} . In fact, the experiments of Randel Mills suggest $h = 6h_0$ [L52]. Mills observed that hydrogen can have states for which binding energy scale is larger than normally: the would correspond to $h_{eff} = nh_0$, n < 6.

Remark: Recall that carcinogens are free radicals with un-paired valence electrons. These valence electrons would be dark.

Model I

What could be the simplest model for the reaction considered? The valence electron of dark hydrogen have spin and in ground state it could be in $n_P = 1$ tilassa (n_P is principal quantum number usually denoted by n). As it absorbs photon it can go to $n_P = 1$ state with larger value of n. One could imagine a two step process

$$(n_1, n_P) = (7, 1) \to (n_2 = 8, 1) \to (n_3 = 6, 1)$$
.

Could the incoming and outgoing energies be identified as energies for the transitions involved. The energies are 2.43 eV ja 5.95 eV. The actual values are 3.27 eV ja 5.69 eV. I have not found better fit so that Model I fails.

Model II

Let us assume a lonely dark valence electron seeing the atom effectively as hydrogen. The key observation is that $h_{eff}/h = 2$ corresponds to $n = 12 = 2 \times n_0 = 12$ with ionization energy $E_I(n = 12) = 3.4$ eV. This is not far from $E_{12} = 3.27$ eV.

Could an almost ionization from the n = 12 ground state with $n_P = 1$ to state $n_P = m$ occur and be followed to a state with n < 12 state, possibly ground state with $n_P = 1$ with an emission of photon with energy $E_{23} = 5.69 \text{ eV} > E_{12} = 3.27 \text{ eV}$? One would have $(n_i = 12, 1) \rightarrow 1000 \text{ eV}$ $(n_i = 12, m) \to (n_f, 1).$

- 1. It is easy to see that one can have only $n_f = 9$ giving $h_{eff}/h = n_f/n_0 = n_f/6 = 3/2$. This would give ionization energy $E_I(i, n = 9) = 6.0$ eV.
- 2. One should have $E_{23}/E_I(n=9) = E_{12}/E_I(n=12) = 3.27/3.4 = .96$. The ratio of excitation energy and ground state energy would be same for initial and final state. The transition to the state $n_P = 5$ predicts $r = E_{12}/E_I(n = 12)1 - 1/25 = ...96$. The prediction is correct.

For the final state photon the prediction would be $E_{23} = (3.27/3.4) \times 6 \text{ eV} = 5.77 \text{ eV}$. The actual value is 5.69 eV. The error of the prediction is about 2 per cent.

Notice that the dark hydrogen model is extremely general and explains why so many carcinogens have this same signature. One must however notice that the orbital radius of the dark electron must be larger than that of other electrons for a screening to unit charge to take place. In the earlier applications I have assumed that the principal quantum number n_P dark valence electron is not smaller than that for the valence electrons of the ordinary atom. Also the weaker condition $n_P n > k$, where k is the principal quantum number for valence electrons, guarantees this. For hydrogen atom the condition gives no constraints but for k: th row of the periodic table one must have $n_P n > k$ (or even $n_P \ge k$). In the above model $n_P = 1$ allows only hydrogen atom. Only H and C atoms are present in carbohydrates and C has no lonely valence electrons to that the condition is automatically satisfied for them.

A model for the observations of Veljkovic 10.2.4

There is also an article of Veljkovic about carcinogens [I133]. The article tells that the wavelength range is 206-248 nm: this would correspond to the energy range 6.1-5.0 eV in UV. On the other hand, it is noticed that the most carcinogenic wavelength range is 232-278 nm, which would correspond to the energy range 5.3-4.5 eV in UV. It would seem to me that there is a mistake in the article of Veljkovic: the upper end for wavelength range should be either 248 nm or 278 nm for both ranges. Could it be that the maximal wavelength range is 206-278 nm? TGD based model supports this interpretation as will be found.

In the first table of the article 4 absorption wavelengths have been listed for the molecules appearing in it and on basis of the summary only the lowest wavelengths can be carcinogenic.

Veljkovic does not mention the wavelength 380 nm. This suggests that this wavelength is not carcinogenic as such. On basis of what has been said the transition

$$(n = 12, 380 \ nm) + X \rightarrow (n = 9, 218 \ nm) + X$$

would take place. X could be a atom in bio-molecule or in carcinogen as was assumed. It is enough that dark valence electron is in question. This process would transform dark n = 12photon to dark n = 9 photon. $(n = 12, n_P = 1)$ dark electron would go to the intermediate state $(n = 12, n_P = 5)$ and from it to $(n = 9, n_P = 1)$ dark valence electron. The reduction of h_{eff}/h_0 would mean a reduction of "biological IQ" for both dark photons and dark electrons. Could this be enough for carcinogenic effect?

One could argue, that the any molecule containing an atom with dark n = 12 valence electron makes it carcinogenic. This cannot be true. Carcinogen must have some additional property. Could it be that $(n = 9,218 \ nm)$ dark photons transforms to bio-photon, which is absorbed by the an ordinary electron of carcinogen, so that biological IQ is reduced further. The transformation to ordinary photon followed by absorption would be single quantum process. Note that the absorber could be also second carcinogen atom for which the absorbing valence electron is ordinary. Carcinogenicity would follow from the existence of an ordinary electronic state, which can be excited by the photon produced $(n = 12, 380 \text{ } nm) + X \rightarrow (n = 9, 218 \text{ } nm) + X$.

Assume that the transitions are those of ordinary electrons of the carcinogen. For some value of $h_{eff}/h_0 = n$ the energy range 5.0-6.1 eV could correspond to spectral lines for dark transitions of some kind creating the absorbed photons transforming to bio-photons in absorption. One can imagine two options.

Option I: The spectral lines could coincide for those for the transitions of dark hydrogen from excited state to ground state or excited state. This model turns out to be too simple to explain the observations of Veljkovic.

Option II: The spectral lines could co-incide for to those for Popp's transitions $(n = 12, n_P = 1) \rightarrow (n = 12, n_{P,i} > 1) \rightarrow n(n = 9, n_{P,f} \ge 1)$. This model can explain the observations of Veljkovic satisfactorily and suggests also a possible interpretation for the metabolic energy quantum and Coulomb energy assignable to the membrane potential. Note that only dark valence electron of hydrogen atom can be considered and this is the only possibility for hydrocarbons.

Option I

The transition energies of dark hydrogen characterized by n are given by

$$\frac{\Delta E}{E_H} = \left(\frac{6}{n}\right)^2 \left[\frac{1}{n_{P,f}^2} - \frac{1}{n_{P,i}^2}\right] . \tag{10.2.1}$$

The simplest option is that the transition takes place to the ground state with $n_{P,f} = 1$.

For what value of $h_{eff}/h_0 = n$ energy range 5.0-6.1 eV could correspond to the spectral lines of dark hydrogen? Ionization energy for dark hydrogen gives the largest energy and it should be around $E_{max} = 6.1$ eV. If ionization does not take place, photon energy is lower and could correspond to energies in the range 5.0-6.1 eV. With these assumptions one obtains

$$E_H(n) = E_H \times (\frac{h}{h_{eff}})^2 = E_H \times (\frac{6}{n})^2 = E_{max}$$
, $E_{max} = 6.1 \text{ eV}$, $E_H = 13.6 \text{ eV} (10.2.2)$

This gives $n^2 = 80.26$ so that n is very near to n = 9 and $h_{eff} = 3h/2$. n = 9 gives upper bound $E_{max} = 6.04$ eV. Also other energies could correspond to the transitions of dark hydrogen. The transition would be of for $(n_P \rightarrow n_P = 1)$ and the energy of the emitted photon would satisfy the condition

$$\Delta E = E_{max}(1 - n_P^{-2}) = E_{min} = 5.0 \text{ eV} . \qquad (10.2.3)$$

This would give $1/n_P^2 = 1/6$ in a reasonable approximation. This cannot be true. What if one uses as the lower bound the energy $E_{min} = 4.5$ eV, which corresponds to 278 nm. This would give m = 2for $E_{max} = 6$ eV! The maximal range 206-278 nm would correspond to the emission spectrum for the transition to the ground state. Getting dark counterparts for the absorbtion energies listed by Veljkovic does not however seem probable since there is only single integer valued parameter available.

Option II

The energy of the photon is difference of $n_f = 9$ and $n_i = 12$ excitation energies characterized by $n_{P,f}$ ja $n_{P,i}$. The general formula for the transition energy ΔE allowing n_f and n_i to be arbitrary reads as

$$\Delta E = \left[\frac{1}{n_{P,f}^2} \left(\frac{6}{n_f}\right)^2 - \frac{1}{n_{P,i}^2} \left(\frac{6}{n_i}\right)^2\right] E_H \quad . \tag{10.2.4}$$

For $n_i = 12$ with $h_{eff} = 2h$ and $n_f = 9$ with $h_{eff} = 3h/2$ one obtains the formula

$$\Delta E = \left[\frac{4}{9n_{P,f}^2} - \frac{1}{4n_{P,i}^2}\right] E_H \quad , \quad E_H = 13.6 \text{ eV} \quad . \tag{10.2.5}$$

Consider first the dependence of ΔE on n_i for given n_i .

- 1. Consider first the situation for $n_{P,f} = 1$.
 - (a) ΔE is largest at the limit $n_{P,i} \to \infty$: this gives $\Delta E = (4/9)E_H = 6.04$ eV ($\lambda = 205$ nm), which corresponds to the upper bound for energies deducible from the results of Veljkovic. This energy is also largest possible since the scale of ΔE is proportional to $1/n_{P,f}^2$.
 - (b) One obtains minimum of ΔE for for $n_{P,i} = 1$ as $\Delta E = 2.64$ eV ($\lambda = 469$ nm, blue). One therefore obtains has a band [2.64, 6.04] eV of lines become dense at its UV end.
 - (c) For $n_{P,i} = 2$ gives ($\Delta E = 5.19 \text{ eV}$, $\lambda = 239 \text{ nm}$). The wavelength is near to the lower bound of the wavelength range 232-278 nm mentioned by Veljkovic. For $n_{P,i} = 3$ one obtains ($\Delta E = 5.67 \text{ eV}$, $\lambda = 219 \text{ nm}$). The wavelength approaches to the limit 205 nm at the limit $n_{P,i} \to \infty$. The wave lengths are very densely spaced for large values of $n_{P,i}$ could well correspond in good enough approximation to the wavelengths near the lower boundary of the wavelength range given by Veljkovic.
- 2. $n_{P,f} = 2$ gives the upper bound $\Delta E = 1.5$ eV for $(n_{P,i} \to \infty \text{ in near infrared } (\lambda = 821 \text{ nm})$. Lower bound $\Delta E = .67$ eV is obtained for $n_{P,i} = 2$. One has therefore band [.67,1.5] eV with density of lines getting dense in near infrared. Quite generally, for $n_{P,f} \ge 2 \Delta E$ is below UV range and arbitrary small values of ΔE are possible for large enough values of $n_{P,f}$.
- 3. $n_{P,f} = 3$ gives the upper bound $\Delta E \leq .67$ eV for $(n_{P,i} \to \infty$ and lower bound $\Delta E = .294$ eV for $n_{P,i} = 3$. Metabolic energy quantum with value of .5 eV is included in this range of energies and $n_{P,f} = 9$ gives $\Delta E = 4.45$ eV.

Consider next the minimal values of the energy for given $n_{P,f}$.

1. The condition $\Delta E \ge 0$ gives $n_{P,f} \le 4n_i/3$. For $(n_{P,f}, n_{P,i}) = k(4,3)$ one has $\Delta E = 0$. For $n_{P,f}$ integer nearest to but smaller than $n_{P,f} = 4n_{P,i}/3 - 1$ one has smallest value of ΔE for given $n_{P,i}$. The following formula for ΔE for $n_{P,f} = 4n_{P,i}/3 - 1$ is true for $n_{P,i} = 3k$:

$$\Delta E_{in}(n_{P,i}) = \left[\frac{4}{9}\frac{1}{(4k-1)^2} - \frac{1}{36k^2}\right]E_H \simeq \frac{E_H}{72k^3} \simeq \frac{.19 \text{ eV}}{k^3} \text{ for } k \to \infty \quad . \tag{10.2.6}$$

- 2. For k = 1 $(n_{P,i} = 3)$ one obtains $(\Delta E = .66 \text{ eV}, \lambda = 1879 \text{ nm})$. ΔE is slightly higher than the nominal value .5 eV of the metabolic energy quantum.
- 3. For k = 2 $(n_{P,i} = 6)$ one obtains $\Delta E = .065$ eV, which corresponds to a typical membrane potential.

To summarize, Popp transition energies of dark valence electrons of dark hydrogen atom might explain not only the energies listed by Veljkovic but also metabolic energy quantum and Josephson energy assignable to cell membrane in TGD based model of cell membrane as generalized Josephson junction.

10.2.5 Could the dark photons from Popp transitions transform to biophotons?

Bio-photons do not seem to be produced by molecular transitions although they can induce molecular transitions about which the transitions of carcinogens would be and example. I have proposed earlier that bio-photons include dark cyclotron photons with harmonic oscillator spectrum. Spectra for several strengths of magnetic field are required to get a quasi-continuum believed to characterize bio-photons. For dark cyclotron photons also the value of $h_{eff} = h_{gr}$ would be very large [K95] [L81]. The photons emitted in the transitions of dark valence electrons with relatively small value of h_{eff} serve also as a candidate for dark photons transforming to bio-photons. They could be assigned to the parts of the magnetic body with relatively small size scale (say flux tubes connecting cells) unlike those with large value of h_{eff} and wavelengths even of order those of EEG photons.

Bio-photons include also visible wave length range. Do the transitions of dark hydrogen allow to cover this range? Besides the above kind of transitions reducing h_{eff}/h , one can also consider the transitions increasing it. One might argue that the transitions responsible for color vision are of latter type since negentropy increase is involved.

The following **Tables 10.1** and **10.2** describe the energies of emitted photons in processes $(n_i \rightarrow n_f)$ with $n_{P,i} = 1$ in the case that they are kinematically possible. n_i and n_f are allowed to vary in the range (9, ..., 17) so that transitions which either increase or reduce h_{eff}/h , or leave it unaffected, are allowed.

Remark: The condition $n_{P,i}n_i > k$, where k is principle quantum number for the valence electrons of the ordinary atom guarantees the screening to unit charge. $n_{P,i} \ge k$ assumed in earlier models would be stronger condition. Similar condition must be satisfied by $n_{P,f}$: the transitions with $n_{P,i} \le n_{P,f}$ are always possible.

- 1. The rows of the tables with fixed n_i give the minimum value $n_{P,f,min}$ of $n_{P,f}$ determined by the condition that the photon energy ΔE is positive, the energy ΔE_{min} in this case, and the maximum ΔE_{max} for which final state electron is free $(n_{P,f} \to \infty)$. The transitions for $n_{P,f} < n_{P,f,min}$ can occur in reversal time direction as absorption.
- 2. By changing the roles of n_i and n_f and of $n_{P,i} = 1$ and $n_{P,f}$, the same table gives some transition energies with final state electron in the ground state $(n_{P,f} = 1)$. The table also gives minimal absorption energies ΔE_{min} resp. maximal absorption energies ΔE_{min} as function of n_i and $n_{P,i,max}$ resp. $n_{P,i,max}$. Note that the transitions for $n_{P,i} < n_{P,i,min}$ for which photon energy would be negative can occur in reversal time direction as emission.

From the tables one learns that the energies of photons in visible regions can be covered by the scaled variants of the spectra but the regions near the ends have a low density of lines.

- 1. The densities of the spectral lines increase towards the maximal energies $\Delta E_{max}/eV \in$ (1.69, 1.91, 2.18, 2.5, 2.90, 3.40, 4.05, 4.90, 6.04) associated with $17 \ge n_i \ge 9$). The upper ends of the frequency range for $n_i + 1$ are above the lower ends for n_i so that the ranges of energies overlap. The deviation from un-evenness can be testable someday as detection technologies develop.
- 2. As a rule, the spectra for the transitions reducing h_{eff} begin at $n_{P,f} = 2$ since the lowest state would correspond to negative energy. The transition can be however realized in opposite direction as as a transition increasing h_{eff} . I have added to ΔE_{min} column (fourth column) the energy of this transition in brackets.

I have added to ΔE_{min} column (fourth column) 2 spectral lines in brackets to show where the visible part of the spectrum begins in these cases. The reader can compare the spectrum to the data given about the spectrum of visible light (see http://tinyurl.com/q8yqea9).

A couple of comments about the interpretation of the spectrum is in order.

1. The maximum energies for the bands intersecting visible range are $\Delta E \in (1.69, 1.91, 2.18, 2.5, 2.90, 3.40)$ labelled by $17 \ge n_i \ge 12$). Note that upper end of violet is 3.26 eV and belongs to the band [2.55, 3.40] eV containing blue. Could these 6 bands becoming infinitely dense towards their upper ends correspond to the 6 color-complement color pairs red-green, blue yellow and white-black pair included? Could different values of n_i characterize color qualia? Could the ends of the bands be identified as "nominal" wavelengths for the basic colors? Note that I have constructed a model for color vision relying on the transitions of dark electrons in [L84].

2. I have also suggested that music harmony could emerge at the level of fundamental physics [L32, L92], in particular the model for dark genetic code [L79] leads to 12-note scale. An interesting questions is whether the ratios for the frequencies associated with $\Delta E \in (1.69, 1.91, 2.18, 2.5, 2.90, 3.40)$ could correspond to simple music scale. The ratios of the energies to the smallest energy are given by (1.00, 1.13, 1.29, 1.5, 1.72, 2.01). In even tempered scale with the notes of 12-note scale coming as $f_n/f_0 = 2^{n/12}$ one obtains for the pentatonic scale C,D,E,G,A,C appearing in Chinese music the frequencies ratios (1.00, 1.12, 1.26, 1.50, 1.68, 2.00). The deviations are few per cent.

10.3 Possible general mechanisms for the action of carcinogen

In the following some general guesses for the effect of carcinogens are discussed and after that a model based on the findings of Popp and Veljkovic is discussed.

10.3.1 Some general ideas

Consider first some guesses.

- 1. The dark photons of BEC can be absorbed and reduce also reduce the value of n for dark electrons: for instance, in the above example one has $n_i = 12 \rightarrow n_f = 9$.
- 2. This reduction of n for catalyst and return to its original value possibly requiring metabolic energy would be the basic mechanism of bio-catalysis. It would liberate temporarily metabolic energy allowing to overcome the potential wall slowing down the reaction considered.

Carcinogens would imitate other biomolecules in that they would have dark electrons. This might help to get into bio-molecules in this manner (consider bentzene as example). Dark lonely unpaired valence electrons would be in fundamental role. Their transitions would produce a universal spectrum playing a key role in the bio-control.

3. If 3.27 eV:n photons emerge t n = 12 BEC assignable to organism, the presence of carcinogen would lead to a loss of the BEC and production of bio-photons.

If this is the case, the spectra for the transitions $(n_i, n_{P,i} \rightarrow (n_f, n_{P,f}))$ of dark hydrogen atom would define the central frequencies and key energies of bio-control. There would be infinite number of these corresponding to all transitions $(n_1, n_{P,1}) \rightarrow (n_2, n_{P_2})$. Energy difference and at the same time the spectrum of biologically important photons would contain the transition energies of dark hydrogen atom:

$$E((n_i, n_{P,i} \to (n_f, n_{P,f}) = \frac{1}{n^2} \left[\frac{1}{n_f^2} \frac{1}{n_{P,f}^2} - \frac{1}{n_i^2} \frac{1}{n_{P,i}^2} \right] \times E_I(H) , \quad E_H = 13.6 \ eV . \tag{10.3.1}$$

One can say, that these spectra produce a fractal, since they are obtained from each other by scaling using rational number. Here the value of n can be such that the energies are in visible and UV range corresponding to the energy spectrum of bio-photons. The dynamics of living matter would be universal, which conforms with quantum criticality.

One could think that if molecule has in its ordinary spectrum a line coinciding with some energy in above spectrum, the molecule defines a potential carcinogen. All atoms with un-paired valence electron, which can be dark would be potential parts of carcinogen. Some additional condition must be satisfied for a molecule to be a carcinogen: the existence of ordinary transition with energy in the dark photon spectrum could be this condition. There are also other frequency spectra such as cyclotron transitions and also these could couple to carcinogens.

	n_i	n_f	$n_{P,f,min}$	$\Delta E_{min}/eV$	$\Delta E_{max}/eV$	
	9	9	2	4.53	6.04	
T	9	10	1	1.15 (4.82, 5.50)	6.04	
T						
Τ	10	9	2	(1.15) 3.38	4.90	I
Τ	10	10	2	3.67	4.90	I
T	10	11	1	0.85(3.88, 4.45)	4.90	
Π						I
Π	11	9	2	(2.00) 2.54	4.05	I
T	11	10	2	(0.85) 2.82	4.05	Î
T	11	11	2	3.03	4.05	1
Π	11	12	1	0.65 (3.20, 3.67)	4.05	
T						
	12	9	2	(2.64) 1.89	3.40	
	12	10	2	(1.50) 2.18	3.40	
	12	11	2	(0.65) 2.39	3.40	
	12	12	2	2.55	3.40	
	12	13	1	0.50(2.68, 3.08)	3.40	
	13	9	2	$(3.15)\ 1.39$	2.90	
	13	10	2	$(2.00) \ 1.67$	2.90	
	13	11	2	(1.15) 1.89	2.90	
T	13	12	2	(0.50) 2.05	2.90	
T	13	13	2	2.17	2.90	
T	13	14	1	0.40(2.27, 2.62)	2.90	
Τ						
Τ	14	9	2	$(3.55) \ 0.99$	2.50	
T	14	10	2	(2.40) 1.27	2.50	
	14	11	2	(1.55) 1.49	2.50	1
	14	12	2	(0.90)1.65	2.50	1
T	14	13	2	(0.40) 1.77	2.50	1
Γ	14	14	2	1.87	2.50	1
ſ	14	15	1	0.32(1.95,2.26)	2.50	1

Table 10.1: Table represents minimal and maximal dark photon energies $\Delta E_{min}/eV$ and $\Delta E_{max}/eV$ for transitions $(n_i, n_{P,i}) \rightarrow (n_f, n_{P,f})$ in the range $n_i \in [9, 14]$. In the column for $\Delta E_{min}/eV$ numbers in brackets give for $n_f = 1$ rows the $n_{P,i} = 2, 3$ transition energies and for $n_{P,f} = 2$ rows transition energy for the reverse transition $(1, 1) \rightarrow (1, 1)$.

n_i	n_f	$n_{P,f,min}$	$\Delta E_{min}/eV$	$\Delta E_{max}/eV$
15	9	2	(?) 0.66	2.18
15	10	2	$((2.72) \ 0.95)$	2.18
15	11	2	(1.87) 1.16	2.18
15	12	2	(1.22) 1.33	2.18
15	13	2	(0.72) 1.45	2.18
15	14	2	(0.32) 1.55	2.18
15	15	2	1.63	2.18
15	16	1	0.26(1.70, 1.96)	2.18
16	9	2	(4.13) 0.40	1.91
16	10	2	(2.98) 0.69	1.91
16	11	2	(2.13) 0.90	1.91
16	12	2	(1.49) 16	1.91
16	13	2	(0.98) 1.19	1.91
16	14	2	(0.59) 1.29	1.91
16	15	2	$(0.26)\ 1.37$	1.91
16	16	2	1.43	1.91
16	17	1	0.22(1.40, 1.72)	1.91
17	9	2	$(4.35) \ 0.18$	1.69
17	10	2	$(3.20) \ 0.47$	1.69
17	11	2	$(2.35) \ 0.68$	1.69
17	12	2	(1.71) 0.84	1.69
17	13	2	1.20) 0.97	1.69
17	14	2	(0.80) 17	1.69
17	15	2	(0.48) 1.15	1.69
17	16	2	(0.22) 1.22	1.69
17	17	2	1.27	1.69
17	18	1	$0.1\overline{8}$ (1.32,1.53)	1.69

Table 10.2: Table represents minimal and maximal dark photon energies $\Delta E_{min}/eV$ and $\Delta E_{max}/eV$ for transitions $(n_i, n_{P,i}) \rightarrow (n_f, n_{P,f})$ in the range $n_i \in [15, 17]$. In the column for $\Delta E_{min}/eV$ numbers in brackets give for $n_f = 1$ rows the $n_{P,i} = 2, 3$ transition energies and for $n_{P,f} = 2$ rows transition energy for the reverse transition $(1, 1) \rightarrow (1, 1)$.

10.3.2 A proposal for the carcinogenic mechanism inspired by the observations of Popp and Veljkovic

This picture encourages to consider a rather simple mechanism for cancer as a loss of quantum coherence due to the decay of Bose-Einstein condensate of dark photons caused by the presence of carcinogen molecules. Also super conductivity possibly associated with dark valence electrons might be lost. Carcinogen would absorb the n = 9 dark photons ($\lambda = 218$ nm) generated from n = 12 dark photons (for instance for $\lambda = 380$ nm) by Popp mechanism.

Dark photon, call it A, would transform with certain rate $k_{A\to B}$ to ordinary photon (biophoton). Bio-photon would transform with rate $k_{B\to A}$ to dark photon. Carcinogen molecule would absorb bio-photons B with rate k_C . The situation is analogous to a chemical reaction in which second components leaks out from the system by reacting with a third component, whose concentration is assumed to be large. The outcome is that both A and B approach to zero and BEC is lost.

For the densities of photons obtains the equations

$$\frac{dA}{dt} = k_{B \to A}B - k_{A \to B}A \quad , \tag{10.3.2}$$

$$\frac{dB}{dt} = -k_{B \to A}B + k_{A \to B}A - k_CB \quad . \tag{10.3.2}$$

The equations are linear and the solution is sum of two exponent terms with rather free coefficients (A and B must be positive).

The general form for the equations is

$$\frac{dA}{dt} = k_1 B - k_2 A \quad , \tag{10.3.3}$$

$$\frac{dB}{dt} = -k_3 B + k_2 A \quad . \tag{10.3.4}$$

One has

$$k_1 = k_{B \to A}$$
, $k_2 = k_{A \to B}$ $k_3 = k_{B \to A} + k_C$. (10.3.4)

One has $k_3 > k_1$ since B is absorbed by carcinogen.

By using the ansatz

$$A = A_0 exp(-kt)$$
, $B = B_0 exp(-kt)$. (10.3.5)

one obtains a homogenous linear group of two equations and the solutions for k are determined by the vanishing of the determinant of the matrix defining the group

$$k_{\pm} = \frac{k_1 + k_3}{2} \pm \frac{1}{2}\sqrt{(k_3 + k_1)^2 - 4(k_3 + k_2)k_1} \quad . \tag{10.3.6}$$

The general solution is of the form

$$\begin{pmatrix} A \\ B \end{pmatrix} = \sum_{\pm} a_{\pm} exp(-k_{\pm}t) \begin{pmatrix} \frac{k_2}{k_{\pm}+k_1} \\ 1 \end{pmatrix} .$$
(10.3.7)

Both A and B approach zero with an exponential rate.

10.4 Appendix: Number theoretical characterization of the photon spectrum from dark valence electron transitions

The spectrum for the lines of dark photons from the hydrogen-like transitions of dark valence electron can be characterized number theoretically. The reason is that given transition energy is characterized by a pair (k_i, k_f) of products integers $k_i = n_i n_{P,i}$ and $k_f = n_f n_{P,f}$ as

$$\frac{\Delta E}{E_H} = \frac{1}{k_i^2} - \frac{1}{k_f^2} \quad . \tag{10.4.1}$$

For given k_i resp. k_f all its decompositions to a product of integers define one possible initial resp. final state. The spectral density is sum of energy conserving delta functions each multiplied by the number of transitions with the energy consider. This number is proportional to the product $N(k_i)N(k_f)$ for the numbers of these decompositions for k_i and k_f . The spectral density function has therefore a large value when both k_i and k_f have large number of factors.

Could the photons produced in this kind of transitions could be of special physical and biological significance? This could be the case if the number of allowed pairs (n_i, n_f) and $(n_{P,i}, n_{P,f})$ is large enough. Whether this could be the case is an open question. In any case it is interesting to look what this would imply.

One has always the decompositions $(n = 1, n_P = k)$ and $(n = k, n_P = 1)$ and for prime values of k only these decompositions exist. For non-prime values of k there are also decompositions to a product of integers different from k and 1. The number N(k) of factorizations of k into a product of two integers is given by the number of different factors of k. Elementary argument showing that the number of decompositions of p^r equals to $N(p^r) = r + 1$ shows that N(k) is obtained from the prime decomposition $k = \prod p_i^{r_i}$ of k as

$$N(k) = \prod_{i} (r_i + 1) , \quad k = \prod_{i} p_i^{r_i} .$$
(10.4.2)

For numbers k_i having large number of different factors the number of product decompositions is large. For prime values of k_i there are only two compositions. For instance, factorial $k = r! = 1 \times 2 \dots \times r$ the number of decompositions is large. Powers $k = p^r$ have N(k) = r+1 decompositions. Perfect numbers $P = M_p 2^{p-1}$ ($M_p = 2^p - 1$) have large number of composition due to the large power of 2 involved.

An interesting question is, for which kind of integers the number of factors divided by integer is maximal. It is known that N(n) satisfied the inequality $N(n) \leq 2^{1.5379 \log(n)/\log(\log(n))}$ and that equation holds true for N = 6,983,776,800 (see http://tinyurl.com/yar9kdfd and http:// tinyurl.com/y7nvfce5). I do not know whether the equation is true for some other integers. Just for fun one can look the frequency and period associated with the ground state energy of hydrogen atom with $h_{eff} = Nh_0$ assuming $h = 6h_0$. The frequency is $f = (6/N)^2 (E_H/eV) \times (3/1.24) 10^{14}$ Hz giving period T = 1/f = 187.4 h or 7.8 days, with day=24 h.

Assuming that all transitions have the same probability to appear (an assumption very probably non-realistic), one can write the spectral density function as the density of states per energy as a sum of energy conserving delta functions multiplied by the number $N(k_i)N(k_f)$ of transition with this energy

$$\frac{dN}{dE} = \sum_{k_i, k_f} N(k_i) N(k_f) \delta(E - E_{k_i \to k_f}) \quad .$$
(10.4.3)

Therefore the pairs (k_i, k_f) with both integers having large number of factors could be of special interest. In a more realistic treatment each delta function contains an additional weight factor telling the probability for the particular transition to occur.

Acknowledgements: I am grateful for Tommi Ullgren for informing me about the work of Popp and Veljkovic related to the interaction of carcinogens with UV light.

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Chapter 11

About concrete realization of remote metabolism

11.1 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.

11.1.1 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 a 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 3surfaces (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 *frac-tality*. 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 h_{eff} makes possible macroscopic quantum coherence crucial in living matter. For instance, it allows dark ELF photons with energies above thermal energy $(E = h_{eff}f)$.
- **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 $h_{eff}/h = n$. 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 [L30].
- 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 inspire 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 $E_c = hZeB/m$ is much below thermal energy at physiological temperatures and magnetic fields possible in living matter. In the transition $h \rightarrow h_{eff} E_c$ is scaled up by a fractor $h_{eff}/h = n$ and for sufficiently high value of h_{eff} cyclotron energy can be above thermal energy $E = h_{eff}ZeB/m$. 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 $\Delta \Phi(t) = \int ZeV dt/h$ 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 $f_J = ZeV/h$. The frequency for cell membrane is rather high for the ordinary value of Planck constant but $h \rightarrow h_{eff}$ 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 h_{eff} and Josephson energies were the same for them.

• The recent view about *negentropic entanglement* forced by Negentropy Maximization Principle (NMP) [K80] 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 bound-aries 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 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.

11.1.2 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. 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" 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 is 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 is proposed. Also the proposal that neutrino Cooper pairs making sense in TGD framework but not 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 [L31].

11.2 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.

11.2.1 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 comings as square roots of powers of two and defining a hierarchy transition energies which are not identifiable as ordinary molecular transition energies [K17]. 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 $E_{=}h_{eff}f_c$, $f_c = qB/4\pi m$: 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.

11.2.2 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 [I116]. 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 [K20]. The decay rate could be very small so that the intensity of dark photons could be quite high.
- 3. Sleighdogs (see http://tinyurl.com/zg9j3p9) [I44] 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 [I28] 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 ATP \rightarrow ADP fill energy reservoirs at magnetic body?

The best manner to test this is by studying cells under metabolic deprivation. Ling [I87] 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 [K27] 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 [I87] 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.

11.2.3 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 [L57].

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 nutriens: 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.

11.3 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 [H15] (see http://tinyurl.com/hmkhm16) 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 [H3] claiming an independent observation of antimatter galaxies, antimater 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 lense the light rays coming from the other side diverge so that concave lense 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 lense behaves like convex one. Presumably this is not be 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 lense).

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 lense. 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 looks 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 [H9, H6] 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 [J82] 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 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.

11.4 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 [I132, I87, I88, I89, I59, I80, I81]. This theory has several points of contact with the TGD view about living matter and it is interesting to compare the two approaches.

11.4.1 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 [I81] 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 [I88] 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 [I87] is summarized in the article "Main principles of Ling's physical theory of the living cell" (http://tinyurl.com/y7rz5twy) by Vladimir Matveev [I132]. 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 [I87] 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".

$4. \quad \textit{Adsorption of water} \ .$

In Ling's theory the role of water [I59] 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.

11.4.2 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 [K17] Ling's finding [I88] 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 [I80], 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 may 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 [K6]. 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 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 $\hbar \to \hbar_{eff}$, or more generally by $\hbar_{eff,2}/\hbar_{eff,1}$ in the phase transition $\hbar_{eff,1} \to \hbar_{eff,2}$. 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 [K10] 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 $m_i \hbar_{effi,i}$ 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) [L26] [K62] 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, K62].

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 [I81]. 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 [I59]. 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 h_{eff} . The unexpectedly low dissipation indeed served as a partial motivation of Ling in his approach.

11.4.3 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 [L29].
- 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 [K80] is very simple and leads to a connection with dark matter hierarchy, p-adic physics, and quantum criticality [K80] [L27]. 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 co-incide. 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 thing 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 ATP \rightarrow 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 [I88]) 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.

11.4.4 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.

11.5 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.

11.5.1 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

$$J = J_0 sin(\frac{Ze \int V(t)dt}{h_{eff}})$$
(11.5.1)

is running. For a constant resting potential $V(t) = V_{rest}$ one obtains

$$J = J_0 \sin(\omega t) \quad , \quad \omega = 2\pi f_J \quad . \tag{11.5.2}$$

a current oscillating with the Josephson frequency

$$f_J = \frac{ZeV_{rest}}{h_{eff}} \quad . \tag{11.5.3}$$

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 [K48].

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 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

$$f_J = f_{AC} \tag{11.5.4}$$

One can also consider also sub-harmonics:

$$f_J = \frac{f_{AC}}{l}$$
, $l = 1, 2...$ (11.5.5)

so that Josephson radiation would be seen as master and cyclotron radiation as slave. This condition fixes the value of h_{eff} :

$$\frac{h_{eff}}{h} = l \times \frac{ZeV_{rest}}{hf_{AC}} = n = 1, 2, \dots, \ l = 1, 2, \dots$$
(11.5.6)

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 \hbar_{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

$$\Delta \frac{V_{rest}}{V_{rest}} = \frac{l_i}{l_f} - 1 \simeq -\frac{\Delta l}{l} \quad .$$

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.

11.5.2 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} :

$$\Delta(\frac{h_{eff}}{h}) = l \frac{Ze\Delta V_{min}}{hf_{AC}} = lr \frac{Ze^2}{Chf_{AC}} = k \quad . \tag{11.5.7}$$

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

$$\frac{Ze^2}{Chf_{AC}} = s = 1, 2, \dots$$
 (11.5.8)

and that s divides k. This is true for any k for s = 1. This would give a quantization condition for $\lambda_{AC} = c/f_{AC}$:

$$\lambda_{AC} = \lambda_{min} = \frac{\hat{C}}{2Z\alpha} , \qquad \alpha = \frac{e^2}{4\pi\hbar\epsilon_0 c} \simeq 1/137 .$$

$$\hat{C} = \frac{C}{\epsilon_0} , \qquad \epsilon_0 = 8.854 \times 10^{-12} F/m \qquad (11.5.9)$$

Equivalently, one would have

$$f_{AC} = f_{max} = \frac{c}{\lambda_{min}} = \frac{2Z\alpha c}{\hat{C}} \quad . \tag{11.5.10}$$

 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

$$\hat{C} = \frac{\epsilon_r A}{d} \quad . \tag{11.5.11}$$

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

$$\lambda_{min} \simeq \frac{\hat{C}}{m} \times 67.5 \ , \ f_{max} \simeq \frac{1}{\hat{C}/m} \times 4.4 \times 10^6 Hz \ .$$
 (11.5.12)

- 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

$$\hat{C} = \epsilon_r \times \frac{4\pi R^2}{R - \frac{R^2}{R + d}} \simeq \frac{4\pi R^2}{d} = \frac{A}{d} \quad . \tag{11.5.13}$$

In this case one has $f_{max} \simeq 19$ minutes.

11.5.3 Constraint On Cyclotron Frequency

The TGD inspired model of EEG [K48] 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

$$f_J = \frac{f_c}{l}$$
, $f_c = f_{max} = \frac{2Z\alpha c}{\hat{C}}$. (11.5.14)

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

$$L_B = \sqrt{\frac{r_C \hat{C}}{\alpha}} l ,$$

$$\hat{C} = \frac{\alpha}{l} \frac{L_B^2}{r_C} .$$
(11.5.15)

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 $\hat{C} = .62 \text{ m}$ for l = 1. For large neurons with radius of order 10^{-4} m one has $\hat{C} \simeq 12.6 \text{ m}^2$ 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 $\hat{C} \simeq 1.3 \mu$ 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.

11.5.4 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 $E_E \simeq 100 V/m$ 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 $f_J = ZeV/h_{eff}$. 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

$$\frac{h_{eff}}{h} = \frac{ZeV_E}{hf_{AC}l} = n \ , \ l = 1, 2.2, \dots \ , \ n = 1, 2, \dots \ .$$
(11.5.16)

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 $\frac{h_{eff}}{h}$ 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 h_{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 h_{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 h_{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 h_{eff}/h and cell membranes have indeed done just so.

11.5.5 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 leastthe contribution V_E associated with the Earth's electric field - to the Josephson voltage, then the condition $f_J = f_{AC}$ reads as

$$f_J = \frac{ZeV_E}{h_{eff}} = \frac{f_{AC}}{l} = \frac{f_{max}}{l} , \quad f_{max} = \frac{2Z\alpha}{\hat{C}} .$$
 (11.5.17)

The value of h_{eff}/h for $f_{AC} = f_{max}$ would be given by

$$\frac{h_{eff}}{h} = \times \frac{eV_E}{hc} \frac{\hat{C}}{2\alpha l} = n \quad . \tag{11.5.18}$$

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 dendites - 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

$$\frac{h_{eff}}{h} = 1.24 \times 10^8 \epsilon_r xy \times \frac{A}{m^2} \frac{1}{2\alpha l} = n \quad . \tag{11.5.19}$$

This translates to a quantization condition for the area of the plane capacitor:

$$A = nl \times A_{min} , A_{min} \simeq \frac{118}{\epsilon_r xy} (\mu m)^2 .$$
 (11.5.20)

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 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

$$nl = \epsilon_r xy \times 4.56 \times 10^{24} . \tag{11.5.21}$$

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 of $n \sim l$ 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.

11.5.6 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

$$\frac{h_{eff}}{h} = 7.44 \times 10^{14} \epsilon_r y \times \frac{A}{m^2} \times \frac{1}{2\alpha l} = n ,$$

$$A = nl \times A_{min} , A_{min} \simeq \frac{20}{\epsilon_r y} \times (nm)^2 .$$
(11.5.22)

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

$$\hat{C} = \frac{2\pi\epsilon_r \times L}{\log(R_2/R_1)} \tag{11.5.23}$$

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/nmso 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

$$\hat{C} = \frac{2\pi\epsilon_r \times L}{\log(R_2/R_1)} \simeq 14.5\epsilon_r L ,$$

$$f_{max} = 2Z\alpha \times \log(\frac{R_2}{R_1}) \times \frac{c}{2\pi\epsilon_r \times L} \simeq 3.2 MHz ,$$

$$\frac{h_{eff}}{h} = n = \frac{24\pi}{l} \times (L/nm) \simeq \frac{1}{l} \times 75.4 \times (L/nm) ,$$

$$L = nlL_{min} , L_{min} = \frac{1}{24\pi} nm \simeq .13 Angstrom .$$
(11.5.24)

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 [J21] 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 [K62]. $L_{min} \simeq .1$ 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 or 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/yabvl2gs) 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 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) [J41]: 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 couls 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 [I44, I28].

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 [K12] 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 [K27]. 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 [K27].
- 2. The following argument demonstrates that the questionable assumption about Weinberg angle for near to vacuum extremals is actually un-necessary.
- 3. From **Table 11.1** 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.
- 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

				$\alpha + 2$
lon	Na^+	Cl^{-}	K^+	Ca^{+2}
$E_J(.04 \ mV, p = .23)/eV$	1.01	1.40	1.51	1.76
$E_J(.065 \ V, p = .23)/eV$	1.64	2.29	2.69	2.73
$E_J(40 \ mV, p = .0295)/eV$	1.60	2.00	2.23	1.68
$E_J(50 \ mV, p = .0295)/eV$	2.00	2.49	2.79	2.10
$E_J(55 \ mV, p = .0295)/eV$	2.20	2.74	3.07	2.31
$E_J(65 \ mV, p = .0295)/eV$	2.60	3.25	3.64	2.73
$E_J(70 \ mV, p = .0295)/eV$	2.80	3.50	3.92	2.94
$E_J(75 \ mV, p = .0295)/eV$	3.00	3.75	4.20	3.15
$E_J(80 \ mV, p = .0295)/eV$	3.20	4.00	4.48	3.36
$E_J(90 \ mV, p = .0295)/eV$	3.60	4.50	5.04	3.78
$E_J(95 \ mV, p = .0295)/eV$	3.80	4.75	5.32	3.99
Color	R	G	В	W
Emax	2.19	2.32	3.06	2.49
energy-interval/eV	1.77-2.48	1.97-2.76	2.48-3.10	

Table 11.1: 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.

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 [K12] 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.

11.5.7 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 h_{eff}/h is simply the ratio of frequencies: $h_{eff}/h = f_h/f_l$. 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 h_{eff}/h . This would give direct quantitative grasp to evolution as increase of h_{eff}/h .
- 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 [K94] 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 $L_e(167) = 2.5 \ \mu m$ 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 [K72, K70].

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) [F1]. The thickness of Kennelly– Heaviside layer (see http://tinyurl.com/25ur2t1) [F2] 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 litosphere (see http://tinyurl.com/d96kw) [F4] has typical thickness of 200 km (L(239)) whereas oceanic litosphere 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.

11.6 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.

11.6.1 Basic facts

The following summarizes the basic facts about ball lightnings, lightnings, and the Earth's electrosphere.

- 1. Ball lightings 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 lightings (https://cutt.ly/OHkW59F.

The theory of Cameron [D25] 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 [F6, F3] (for the TGD view of lightnins and related phenomena see [K27, K113, K12, K78, K136]). 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.

11.6.2 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 [L119, L120]. 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-organizating 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 [E1] 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 $h_{gr} \rightarrow h$ implying delocalization of dark. A correct value of metabolic energy currency is predicted [L138] 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 h_{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 h to $h_{eff} > h$ 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 [L138] and allows us to understand how DNA could act as a topological quantum computer [L140].
- 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 h_{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 o a pair capacitor plates. Note that ionosphere begins at height of a 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 blog 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 [L138].

Why just the height h_E ?

- 1. p-Adic length scale hypothesis $p \simeq 2^k$ [K74] favours Mersenne primes $M_k = 2^k 1$ (k is prime) and their Gaussian analous $M_{G,k} = (1+i)^k 1$. 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 [L133]. 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 [L133]. 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 [J23] 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 [L138]. 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 Scwartshild 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 [L138].

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 [L138] 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 $h_{eff}/h_{ar} \sim h_E/R_E \sim 1/100$.
- 2. The presence of solar gravitational MB was proposed in [L138]. 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 [L142, L138]. 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 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.

11.7 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 [D10]. Pure silicon is very rare in nature and appears in the forms of Si oxides, silicates, in particular $\text{Si}O_2$ (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 globles 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 [D14].

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 [D15] (see this) is formed as the lightning strikes on the soil and SiO₂ 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 O₂ ions from SiO₂ 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 [L138, L136], and the TGD inspired model of nerve pulse [L157].

11.7.1 TGD view of lightnings

The background for the TGD based model of lightnings and ball lightnings is provided by the TGD view of magnetosphere [K72, K70] [L127] 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 [L153, L154] (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.

EEEG 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 [K103] and its up-to-date version [L157] 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 discusses is formed by the TGD view of magnetosphere [K72, K70] [L127]. 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 [L153, L154].

- 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 [L157] relies on the Pollack effect inducing a charge separation between cell interior/exterior and its MB.

- 1. Pollack effect [I83, L36, I137, I115] 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 H₁.5O 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 fo EZ suggest that second law holds in a reversed time direction and large scale quantum coherence zero

energy ontology (ZEO) [K148], 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 [L157]. 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 [L157]. 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 [K72, K70] [L127, L153, L154] 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 neutrons 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 [K103] [L157].

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 [L157].

- 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 [K103].
- 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 $f_J = ZeV/h_{eff}$. 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 [L153, L154], cyclotron resonance must occur in the receival 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! [L157].

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 $V \to (M/M_E)V$, 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] km. The ratio h_{max}/h_{min} of the maximum and minimum heights is $h_{max}/h_{min} = 32$, which is a power or 2 and brings in mind p-adic length cdale hypothesis.

Note that the scaling down by M_{Moon}/M_E would give V = .5 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 that 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] MeV. A cloud at height of h = 16 km, which is also possible, corresponds to an electrostatic energy in the range [3.2, 9.6] 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 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 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 μ m, size of cell, the next Gaussian Mersenne is G(239) and corresponds to $L(239) \simeq 160$ 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 [K123], 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] 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).

11.7.2 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 [I83, L36, I137, I115] for the water at the soil has somehow generated EZs and SiO₂ 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 SiO₂ crystals would take care of energy conservation. A situation in which part of water corresponds to $H_{1.5}O$ 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 [L138, L136].

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 [K45, K46] 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 SiO₂ 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 [L149, L148], 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 [L148], 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 SiO₂. However, the idea about the local transformation of SiO₂ 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.

11.8 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!

11.8.1 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/ 28nbr) [H1] 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) [H1], 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 co-incidence. 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/25ur2tl) - 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 [H12, H2] (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 the that 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) [H11, H10]. 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.

11.8.2 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 [K21]. 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.

11.8.3 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 [H12, H2] - 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 [K50], 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 [K86] 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:

$$\frac{E_{cr}S}{2e} = n = \frac{h_{eff}}{h} . (11.8.1)$$

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:

$$eV_{cr} = m_e \simeq .5 \quad \text{MeV} \quad . \tag{11.8.2}$$

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 [H13] 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 [K134].

(b) Combining this condition with Eq. 11.8.1 one would have

$$E_{cr} = \frac{V_{cr}}{L}$$
 (11.8.3)

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. 11.8.2. In the case of cell membrane this side effect is used for neural communications using nerve pulses. Conditions of Eqs. 11.8.1, 11.8.2, and 11.8.3 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 $E_d \simeq 3$ 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 11.8.1 gives for $S \in \{1 \ \mu m^2, 1 \ cm^2, 1 \ m^2\}, n \in \{3, 3 \times 10^8, 3 \times 10^{13}\}$. 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

$$J_0 sin(\frac{f_J}{f_{AC}} cos(2\pi f_{AC} t))$$
 , $f_J = \frac{ZeV}{h_{eff}}$,

and periodicity defined by f_{AC} . The sine term would oscillate between values

$$\pm J_0 sin(\frac{f_J}{f_{AC}}) = \pm J_0 sin(\frac{1}{l}) , \ l = 1, 2, \dots$$

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 [K136]. 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:

$$\frac{ZeVT}{h_{eff}} = n ,$$

$$\frac{ZeV}{h_{eff}} = nf , f = \frac{1}{T} .$$
(11.8.4)

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:

$$\frac{ZeV}{h_{eff}} = \frac{f_{AC}}{l} . \tag{11.8.5}$$

The reason is that f_{AC} in general is harmonic of f: $f_{AC} = lf$, l = 1, 2, ... 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 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 $1 \le m \le n$ 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 [K96] 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 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 [K80] 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 μ 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 [K70] 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

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 11.2: 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 scalle) giving $k_{eff} = 213$ (p-adic length scale of 20 meters) and should be assigned with the magnetic body.

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 spacetime sheet with *n* depending on ion.
 - Closed/open ion channel ↔ 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.

- 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 $[L_e(151) = 10 \text{ nm}, ..., L_e(167) = 2.5 \ \mu\text{m}]$ [K70]. 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 [K102] 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 halfseriously. 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 [K27, K48] 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 treshold value of the electromagnetic potential energy via

$$\begin{array}{ll} E(X) = Y(X) \times eV_{crit} &, \\ Y(e) = (-1+x) &, & Y(\nu) = 2-x &, & Y(p) = 3-x &, & Y(n) = x &, \\ x = \frac{1}{2p} &, & p = sin^2(\theta_W) &. \end{array}$$
 (11.8.6)

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 $eV_{crit} \to eV_{crit}/Y(X)$ when Y(X) is near unity. The expressions of Y(X) are deduced in [K27].

2. The earlier model [K27] 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 [K27]. 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 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 [K74]. 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) $eE_E = 100 \text{ eV/m}$ 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).

11.8.4 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" [J9] 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-electromagnetic fields on living matter and 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 [K48]. 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 [K48]. 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 $eV = eEdcos(\theta)$. It is also to the energy received by dark electron as it receives Josephson photon with energy equal to the electrostatic energy $eV = eEdcos(\theta)$. 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, ..., 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 = xV/m with x in the range [1, 10]: $eV = eEdcos(\theta) = eV_{crit} = .055$ eV giving $dcos(\theta) = 5.5/x$ cm. x = 1 corresponds to $cos(\theta) = 1$ giving that the thickness of the Josephson junction is 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.

11.8.5 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 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: $m_e \to m_e/n$, $n \simeq 2^{\Delta k/2}$, $n = h_{eff}/h$. 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

$$J = J_0 sin(\frac{\int dt \Delta V}{h_{eff}}) = J_0 sin[\frac{2\pi}{f_0} \frac{1}{h_{eff}} V(t)] , \quad f_0 = \frac{c}{R\sqrt{1+k^2}} .$$
(11.8.7)

3. Near zeros of V one has in the first approximation $V(t) = V_0 \omega(t - t_{max})$ and Josephson current behaves as

$$J_0 \sin[\omega_{eff,J}(t - t_{max})] , \qquad (11.8.8)$$

where

$$\omega_{eff,J} = (2\pi)^2 \frac{f_{AC}}{f_0} V_0 \frac{1}{h_{eff}}$$
(11.8.9)

defines the analog of Josephson frequency for effective voltage

$$V_{eff} = (2\pi)^2 \frac{f_{AC}}{f_0} V_0 \quad . \tag{11.8.10}$$

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

$$\frac{Ld^2I}{dt^2} + R\frac{dI}{dt} + \frac{I}{C} = \frac{dV_{ext}}{dt} \equiv g(t) = Asin(\omega_0 t)$$
(11.8.11)

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

$$I_{\pm}(t) = exp(-\Omega_{\pm}t) \ , \ \Omega = \frac{-R}{2L} \pm i\omega \ , \ \omega = \sqrt{\frac{1}{LC} - (\frac{R}{L})^2} \ .$$
(11.8.12)

3. The solutions of inhomogenous equation can be obtained by the variation of coefficients for homogenous solutions that is in the form $I_{\pm}^1 = C_{\pm}(t)I_{\pm}(t)$ and are given by

$$I_{\pm}^{s}(t) = \int_{0}^{t} \frac{g(t)}{L} I_{\pm}(t) dt \times I_{\mp}(t) \quad .$$
(11.8.13)

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 $R/L \to 0$ 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 behaves 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

$$Z = R + iX$$
 , $X = \omega L - \frac{1}{\omega C}$

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 $R \to 0$ 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 suggests 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 carries 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 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 worlds, the derivate 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/ybkl3c8c). The anomalous dimensions and critical exponents do not depend on the details of the system, and one characterize 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 tro 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 [J82]. 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) [H5]. 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 $eVcr = m_e = .5$ 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 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 $Z = R + i(\omega L - 1/(\omega C)) (R, L \text{ and } C$ 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 [K80]. 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.

11.8.6 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 [K26, K114, K101].

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 heff?

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 $h_{eff}/h = E_J/hf_{AC}$ [K12].

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 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 [K48, K101]. This would lead to a generalization of the notion of Josephson junction associated with the transmembrane protein and generalizes $f_J = f_{AC}$ to $\Delta f_c + f_J = f_A C$ 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 is 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} [K69] 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 coilandat 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 $h_{gr} = M_E m(pair) / v_0$, v_0 rotational velocity of Earth, suggests itself now. Z_2 could be the charge 2e of the Cooper pair and Z_2 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 co-incide 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 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 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.

11.9 Teslaphoresis in TGD

I found an interesting popular article about a recently discovered phenomenon christened Teslaphoresis [D7] (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 [D7] (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 (\geq 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 selfassemble 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).

I 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.

11.9.1 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 closed circuir. The dynamics is governed by differential equation

$$L\frac{d^{2}I}{dt^{2}} + R\frac{dI}{dt} + \frac{I}{C} = dV_{ext}(t) \quad .$$
(11.9.1)

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 $(L_{1,1}, L_{1,2}, R_1C_1)$ 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 of 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. CTNs 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 .

11.9.2 How TGD could be involved?

My earlier attempts to understand what happened in Tesla's circuits [K50, K12] 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 $h_{eff} = n \times h$ of Planck constant and thus quantum coherence in length scales scaled up by factor n from what they are usually [?]. 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 [?]ncourages to ask whether the photons become dark at quantum criticality and whether their energies $E = h_{eff} \times f$ are above thermal energy. TGD inspired quantum biology would suggests 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 [K21, K14].

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 zitterbewebung 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 $(1, v(x) \text{ with } 1 - v \cdot v = 0)$. 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 12

Can quantum biology really do without new physics?

12.1 Introduction

I was recently contacted by a friend with whom we have had several interesting discussions about consciousness and neuroscience. She sent several links related to certain aspects of quantum biology about which I had not been aware and these links inspired this article.

12.1.1 Background

One of the proposals of quantum biology is a quantum mechanism for the mysterious looking ability of birds and fishes to find back to the place, where they were born. It is believed that navigation involves detection of the inclination of the local magnetic field of Earth but not its direction as in the ordinary ordinary compass. The alternative option states that birds have an analog of compass in their brain. The challenge is to understand what is the mechanism making possible to get the information about magnetic field and how this information is transformed to a chemical signal and eventually to a pattern of nerve pulses. In TGD framework one can challenge the assumption that the magnetic field of Earth is what makes possible the navigation and even what the navigation means.

Quantum biologists try to solve the problem using standard quantum physics. The formidable looking problem is that the energy scale for magnetic energies is extremely small. In the magnetic field of Earth the magnetic interaction cyclotron energy for electron is by factor of order one million below the thermal energy. If one believes of quantum physics in its standard form, one should understand how it is possible to generate a signal making possible non-trivial chemical effects. The proposal that has gained widest acceptance is known has as radical-pair mechanism (RPM) [I43, I73, I95] and has raised hopes about circumvent this problem.

The answer to the question whether RPM works is very important from the point of view of TGD based explanation for macroscopic quantum effects in living matter since TGD based model involves new quantum physics via the hypothesis that dark matter corresponds to $h_{eff} = n \times h$ phases located at flux tubes of "magnetic body" (MB). If RPM fails, TGD based quantum biology would be the next natural trial (if science proceeded by trying first all options that fail).

I received links to several articles and list them here to help the interested reader. The following list is about phenomena involved.

• Cryptochrome Mediates Light-Dependent Magnetosensitivity of Drosophila's Circadian Clock by Yoshii et al [I71] (see http://tinyurl.com/zvlmxp6). Cryptochrome (CRY) (see http: //tinyurl.com/create.php) has been proposed to be the photoreceptor being involved with both circadian rhythms and magnetosensitivity. In response to light CRY slows down the circadian clock and eventually leads to an arhythmic behavior.

The response to magnetic fields in the range around 3 Gauss (6 times the strength of $B_E = .5$ Gauss) was found to be slowing down of the circadian clock. Clock response to magnetic field

was present in the presence of blue light but absent in red-light illumination. This suggests that the blue light is necessary for any response at all and that magnetic field affects the response.

This response could be understood as the effect as the activation of CRY by the external field but one can consider also more complex mechanisms. This finding is taken as a support for RPM, which predicts that the response depends on wave-length and strength of magnetic field.

• Circadian and Geotactic Behaviors: Genetic Pleiotropy in Drosophila Melanogaster by Clayton [I46] (see http://tinyurl.com/j4vmr8c) tells about correlation between circadian rhythms and gravitaxis (geotaxis). The following excerpt from the abstract gives some idea about the findings.

Two of these genes, cryptochrome (CRY) and Pigment-dispersing-factor (PDF) are integral to the function of biological clocks. PDF plays a crucial role in maintaining free-running circadian periods. The CRY gene alters blue-light (< 420 nm) phototransduction which affects biological clocks, spatial orientation and taxis relative to gravity, magnetic fields, solar, lunar, and celestial radiation in several species. The CRY gene is involved in phase resetting (entrainment) of the circadian clock by blue light (< 420 nm).

The following articles are about radical-pair mechanism.

• Chemical magnetoreception in birds: The radical pair mechanism by Rodgers and Hore [I43] (see http://tinyurl.com/zsg4b95).

The abstract of the article is too long to be attached here but very informative and honestly tells the situation in the field. Abstract describes the basic problem that RPM must solve: the magnetic interaction energy of electron with the Earth's magnetic field is by 6 orders of magnitude too low. The abstract also mentions that with few exceptions RPM has been observed only in magnetic field intensities 10 Gauss- 10 Tesla. The exception would be avian compass and photosynthesis! The strength of 10 Gauss field is 50 times higher than the strength of Earth's magnetic field of $B_E \sim .5$ Gauss so that it is far from proven that RPM could be behind the avian chemical compass and unreasonable effectiveness of photosynthesis. Quantum biology might require new physics!

• The Radical Pair Mechanism and the Avian Chemical Compass: Quantum Coherence and Entanglement by Zhang et al [I73] (see http://tinyurl.com/zvcguuz).

The abstract gives brief summary of the radical pair mechanism.

We review the spin radical pair mechanism which is a promising explanation of avian navigation. This mechanism is based on the dependence of product yields on 1) the hyperfine interaction involving electron spins and neighboring nuclear spins and 2) the intensity and orientation of the geomagnetic field. This review describes the general scheme of chemical reactions involving radical pairs generated from singlet and triplet precursors; the spin dynamics of the radical pairs; and the magnetic field dependence of product yields caused by the radical pair mechanism. The main part of the review includes a description of the chemical compass in birds. We review: the general properties of the avian compass; the basic scheme of the radical pair mechanism; the reaction kinetics in cryptochrome; quantum coherence and entanglement in the avian compass; and the effects of noise. We believe that the quantum avian compass can play an important role in avian navigation and can also provide the foundation for a new generation of sensitive and selective magnetic-sensing nano-devices.

The basic idea of RPM is that the creation of electron pairs in states, which are quantum coherent superpositions of spin singlet and triplet states of two electrons, have hyperfine magnetic interactions with nuclear spins giving rise to anomalously large EPR and NMR signals. The small mass of electron is essential but still the problem in the case of avian compass and photosynthesis is to understand how quantum coherence time can be long enough for large enough effect to result before the neutralization of the radical pair.

• The radical-pair mechanism as a paradigm for the emerging science of quantum biology by Kominis [I95] (see http://tinyurl.com/glegn3u).

The radical-pair mechanism was introduced in the 1960's to explain anomalously large EPR and NMR signals in chemical reactions of organic molecules. It has evolved to the cornerstone of spin chemistry, the study of the effect electron and nuclear spins have on chemical reactions, with the avian magnetic compass mechanism and the photosynthetic reaction center dynamics being prominent biophysical manifestations of such effects. In recent years the RPM was shown to be an ideal biological system where the conceptual tools of quantum information science can be fruitfully applied. We will here review recent work making the case that the RPM is indeed a major driving force of the emerging field of quantum biology.

The claim RPM as a new paradigm could be motivated by the observation that radical pairs are formed also in the photosynthesis. As already found, the problem is that the magnetic field of Earth is only two percent of the minimal value of the magnetic field needed for RPM according to the laboratory experiments.

It is worth of emphasizing that RPM was introduced as early as 1960's to explain anomalously large EPR and NMR signals in chemical reactions of organic molecules. In TGD I ended up to the hypothesis h_{eff} hypothesis [?] and stronger $h_{eff} = h_{gr}$ hypothesis [K95] through the attempt to understand the observation of the pioneers of bio-electromagnetism (see for instance [J23, J29, J30] that ELF radiation in EEG frequency range has quantal looking effects on living matter at harmonics of cyclotron frequencies of biologically important ions in endogenous magnetic field $B_{end} = .2$ Gauss, which might correspond to the field strength at the flux tubes of Earth's magnetic field inside organism tuned to give rise to cyclotron frequencies ideal for biology. Cyclotron energies for ions are ridiculously small as compared to thermal energy and large h_{eff} seemed to be the only possible explanation. Could large h_{eff} effects been observed already around 1960's without realizing that new quantum physics is in question?

12.1.2 Some hints

It seems that several biological phenomena could use the same mechanism - RPM would be this mechanism if standard quantum theory is enough to understand these phenomena.

- 1. Magneto-sensitivity and circadian clock seem to be related: light-activated photoreceptors cryptochromes (CRYs) serve also as magnetic sensors and the external magnetic fields slow down circadian rhythm.
- 2. Also gravitaxis that is the ability to move in direction parallel or opposite to the gradient of local gravitational field could relate to this mechanism. This requires that organism is able to perceive the gradient for the strength of the local gravitational field.

Blue light is necessary for the *chemical* magnetoreception and the establishment of circadian rhythm with period of order 24 hours. This is an important hint but leaves much open. Is just the presence of blue light enough for establishing to put the circadian clock ticking or does the periodic variant of the amount of blue light give rise to internal clock?

Blue light seems to have health effects. For instance, exposure to blue light at night time could be harmful to health (see http://tinyurl.com/mggpafe). In particular, too much blue light at night time could affect the circadian clock and too much blue light could lead to sleep disorders and various negative health effects such as several types of cancer (breast, prostate), diabetes, heart disease, and obesity. It is known that the amount of blue light correlates with melatonin secretion. Could the periodic variation of the intensity of blue light give rise to internal clock. Of course, there are very probably several cues used by internal clock (for instance, birds are not dead

matter behaving as robots!) and the variation of the intensity of blue light could be only one of them.

It has been also found (see http://tinyurl.com/zvlmxp6) that the presence of external magnetic fields in the range around 3 Gauss (Earth's magnetic field has nominal value .5 Gauss so that this field is 6 times stronger) tends to increase the period of the circadian clock. This would suggests that the clock in question does not use only the amount of blue light as a cue.

Before continuing it is good to list some abbreviations. Electromagnetic (em), Exclusion Zone (EZ), radical-pairing mechanism (RPM) are standard notions. At least for TGD inspired notions appear in the sequel: Topological Geometrodynamics (TGD), Strong form of Holography (SH), Zero Energy Ontology (ZEO), Causal Diamond (CD), Magnetic Body (MB), Biological Body (BB).

12.2 How to understand circadian clock, magneto-sensing and gravitaxis in TGD framework?

That photoreceptors responsible for circadian rhythms are involved with magnetoreception and the presence of blue light is necessary for magnetoreception are the basic challenges for any model. In RPM model this would follow from the assumption that blue light generates radical-pairs interacting with magnetic field but why just RPM should be crucial for photoreception? Why not some "easier" mechanism? Could bio-rhythms be due to some deeper quantum mechanism involving magnetic fields in an essential manner? Of course, RPM could still be involved but with nonstandard value of Planck constant if TGD view is correct. Non-standard value of Planck constant could be involved even with the original anomalies associated with EPR and NMR.

I have described briefly what TGD is in the Appendix and recommend it for the reader before continuing.

12.2.1 Basic problems and basic principles

In Appendix I summarize what TGD and TGD inspired theory of quantum biology and quantum consciousness are. Here I just list the basic ideas relevant to the model considered. The basic elements of this model are MB following from the many-sheeted view about space-time and distinguishing between TGD and Maxwell's theory and the hierarchy of Planck constants $h_{eff} = n \times h$ possibly satisfying the additional constraint $h_{eff} = h_{gr}$ giving connection with quantum gravity which would allow macroscopic quantum phases in arbitrarily long length scales in TGD Universe.

The key principles and mechanism should be same as in TGD based model of quantum biology.

- 1. Magnetic body (MB) of living organism has a fractal structure corresponding to body parts labelled by corresponding cyclotron frequency scales. MB serves as an intentional agent receiving sensory data from biological body (BB) and controlling it. BB and MB must communicate and dark photons would make this possible. EEG would be one example of this communication and MB would receive by sensory data from cell membrane as dark generalized Josephson photons and control BB by dark cyclotron photons with the mediary of genome (at least) [K48, K105, K103]. EEG would generalize to other frequency ranges and generalized EEG rhythms could emerge in this manner. Dark phases of matter emerge at quantum criticality which is central element of the model. As a matter fact, TGD Universe is in well-defined sense quantum critical.
- 2. One cannot avoid the following questions. Is the avian navigation an automatic process. Could MB control it? Is conscious intelligence and volition involved so that the mechanism in question would be only a tool. Is the MB in question that of species or does the bird decide whether to follow the flux tubes of the personal MB connecting the bird to where it was born or in the horizontal direction defined by the MB of Earth? One must leave these questions open although the idea that the bird follows the horizontal flux tubes connecting it to the birth place (and assignable to the species?) is very attractive and would not favor the flux tubes of Earth which are not horizontal.

- 3. Quantum criticality allows several values of Planck constant are possible. The interpretation is in terms of long range as quantum fluctuations and quantum coherence in various length scales would have a universal explanation. Quantum criticality would be a general property of living matter and crucial also now.
- 4. The most economic assumption is that the mechanism is same as in the case of cell membrane identified as generalized Josephson junction coding nerve pulse sequences and membrane oscillations to EEG and in this manner sending sensory information to MB of the brain. I have indeed proposed long time ago that also biomolecules act as Josephson junctions. In fact, the cell membrane identified as generalized Josephson junction reduces microscopically to an array of generalized Josephson junctions defined by membrane proteins. For generalized Josephson junction Josephson energy 2eV for Cooper pair is replaced with its sum with the difference of cyclotron energies at different sides of the cell membrane. Electronic Cooper pairs would be naturally involved but also bosonic ions and Cooper pairs of fermionic ions can be considered for large values of h_{eff} and are indeed in crucial role in TGD based model of cell membrane.

One of the first applications of TGD inspired biology was the explanation of so called Comorosan effect [I125, I42] in terms of bio-molecular Josephson junctions [K147]. The model assuming generalized Josephson junctions applies in the case of general biomolecules and suggests that there is universal 5 second Josephson time involved. This would require rather large value of h_{eff} (Josephson frequency is inversely proportional to $1/h_{eff}$) since the voltage involved is expected to be rather high in molecular length scales.

5. The basic assumption would be that blue light kicks the photoreceptor CRY to an excited state, which is quantum critical and generates large h_{eff} phases possibly satisfying also the $h_{eff} = h_{gr}$ condition with several values of h_{eff} at the flux tubes. Note that each flux tube carries only one kind of charged particle if it corresponds to a unique value of Planck constant. Dark charged particles are like books on shelves and the situation is just the opposite for the random dense soup of bio-molecules assumed in standard biochemistry.

The basic prediction would be the dependence of the effect on strength of magnetic field as in case of RPM. The slowing down of the rhythm in presence of external B_E could be understood if the cyclotron energy difference in B_E between ground state and excited state changes so that the energy difference becomes smaller and flux tube in question has smaller value of B_{qal} : this could be due to the change of the net charge of the molecule.

One should explain several phenomena using the same model.

1. Navigation involving perception of Earth's magnetic field, which possibly weakens to endogenous magnetic field which is 2/5 of it inside brain. A constraint to h_{eff} emerges from the condition that cyclotron frequency is in visible-UV range.

If one demands $h_{eff} = h_{gr} = GM_Dm/v_0$ one finds that dark mass M_D is of order $10^{-4}M_E$ and that it would correspond to a spherical layer of dark mass at distance of Moon. Skeptic of course begins to talk about Occam's razor. This layer is however natural in the model of dark matter. One could of course just speak about h_{eff} and forget $h_{gr} = h_{eff}$. The important point is that the notions introduced are not ad hoc notions but follow naturally from the very general assumptions of TGD as unification of fundamental interactions (see Appendix).

2. The challenge is to understand circadian rhythm with period about 24 hours. There is some evidence for the importance of the galactic magnetic fields for living matter. One such piece of evidence is the observation that the occurrence of tinnitus seems to appear rhythmically but with respect to galactic time. Galactic magnetic field of strength of about 1 nT could provide explanation. There is also earlier rather mysterious observation that precognition events seem to occur near galactic midday [J78]: this observation is of course not taken seriously by skeptics but deserves to be noticed. A possible test for the TGD based model is that the bio-clock actually measures sidereal rather than circadian time.

The galactic cyclotron time for h_{gr} associated with Earth mass M_E is very natural if flux tubes carry Earth's gravitational field - is very near to 12 hours for galactic magnetic field a

fraction of nT. Cyclotron frequency would generate the biorhythm in manner analogous to that happening in the case of EEG. Only frequency scale would be much longer.

More precisely, according to the estimate of [?] the cyclotron time of DNA in B_{end} equal to 1 s is scaled up to 11.7 hours in B_{gal} =.63 nT. This estimate is obtained by accepting the $h_{eff} = h_{gr} = GMm/v_0$ hypothesis by identifying M as Earth's mass, and by assuming that the parameter $r = v_0/v_{rot,M}$ for Earth has the same value as for Sun. One has $v_0 \simeq 2^{-11}$ for Sun from the Bohr orbit model for the orbits of the 4 inner planets originally proposed by Nottale and v_{rot} is the rotational velocity of Sun.

It is needless to emphasize that this estimate involves uncertainties and that the value of B_{gal} assignable to the flux tubes has a distribution, which could be as wide as that for the energies of bio-photons. There are however good hopes of obtaining the circadian (or possibly sidereal) rhythm with natural choice of parameters.

3. The TGD description of gravitaxis should involve the flux tubes carrying gravitational flux of Earth. The same mechanism might be behind ordinary sensing of the gravitational acceleration. A good guess is that this magnetic field has same strength as galactic magnetic field B_{gal} to which Earth's mass would be associated via h_{gr} . The h_{eff} should be correspondingly higher to guarantee that dark cyclotron energy is in visible-UV range. The energy of blue light is good candidate now for exciting the quantum critical state in which this value of h_{eff} is realized.

Gravitaxis would require the detection of the strength of Earth's gravitational field coded into the density of flux tubes parallel to it. The system should be able to detect the density of the flux tubes and this would occur naturally at quantum criticality via reconnections with these flux tubes and involving dark photons with energies in visible-UV range.

4. Two magnetic fields B_{end} and B_{gal} would be involved as also two values of Planck constant but cyclotron energies would be same and in bio-photon energy range. The two MBs should be able to communicate and one can consider the possibility that the spectrum of ionic cyclotron frequencies for $B_{end} = .2$ Gauss in EEG range corresponds to electronic cyclotron frequencies for a spectrum of values of G_{gal} . This assumption would fix the parameters of the model to very high degree. Interestingly, according to TGD based quantum model for hearing [K102], the audible frequencies would be coded by the thickness of flux tubes (or equivalently by the value of the magnetic field) and galactic flux tubes would give rise to a similar coding. Could hearing actually use the flux tubes of B_{gal} ?

If so, the ranges for audible frequencies and for bio-photon energies measured as number of octaves would be same. The range of frequencies audible for humans is about 10 octaves beginning from 20 Hz. Hence the spectrum of bio-photons should extend from say 1 eV to 10 keV. Dark IR photons are also predicted as a Josephson radiation from cell membrane with energies of photons of order $2eV \sim .1$ eV (Coulomb energy of Cooper pair assignable to cell membrane Josephson junction and roughly twice the thermal energy $E_{th} = 3T/2 \simeq .5$ eV at physiological temperature 330 K). I do not know whether IR energies are excluded as bio-photon energies and therefore whether the range of bio-photon frequencies could actually begin from .1 eV. If so, bio-photon energies would extend up to 1 keV.

It is important to notice that the MB involved with navigation could be Earth's MB or galactic MB if its flux tubes correspond to personal MB of the organism connecting it to its birth place. It is quite possible that both MBs are be involved. One can imagine endless variety of models and the proposed model can be defended by the fact that it is based on the same mechanism as the quantum model for communications between BB and MB giving as special case the model of cell membrane.

12.2.2 Could circadian rhytms be analogous to EEG rhythms in TGD Universe?

In TGD Universe it is natural to think that the circadian rhythms and in fact all biorhythms - are basically analogous to EEG rhythms.

- 1. In TGD EEG frequencies would correspond basically to cyclotron frequencies in and endogenous magnetic field of .2 Gauss which is 2/5:th of Earth's magnetic field carrying dark particles (in TGD sense) having non-standard value $h_{eff} = n \times$.
- 2. The energies of cyclotron photons, which would be extremely small and much below thermal energy for the ordinary value of Planck constant, are scaled up by factor n by $E = h_{eff} \times f$ formula and can have non-trivial biological effects.
- 3. A further proposal is that the formulate $h_{eff} = h_{gr} = GMm/v_0$ holds true at least for large values of h_{eff} . Here h_{gr} is gravitational Planck constant assignable to magnetic flux tubes mediating gravitational interaction, v_0 is a parameter with dimensions of velocity, mis the mass of the dark charged particle at the flux tubes, and M is some large mass.

This formula guarantees that cyclotron energies proportional to $h_{gr}eB/m$ do not depend on the mass m of the charged particle for given charge. This in turn implies that dark cyclotron energy spectrum is universal. The hypothesis is that the transformation of dark photons to ordinary photons produces ordinary photons identifiable as bio-photons. If so the energies would be in visible-UV range and would dark photons could induce transitions of biomolecules and could serve as a biochemical control tool of the MB. If one accepts $h_{gr} = h_{eff}$ hypothesis for EEG, the value of the mass M should be around $M = M_D \sim 10^{-4}M_E$ for EEG. Using some additional cues given by TGD based view about how planets were condensed around dark matter blobs forming spherical cells or tubes around Sun or actually any astrophysical object, I have proposed a possible identification of M_D as a mass of spherical shell of dark matter assignable to Earth at the distance of Moon [?, K95]. Here skeptic of course has an excellent opportunity to introduce Occam's razor and I am of course ready to consider also the option that $h_{eff} = h_{gr}$ does not hold true at the flux tubes of B_{end} .

What about the identification of circadian rhythms as cyclotron frequencies?

- 1. The general idea is that the flux tubes of both Earth's magnetic field and of galactic magnetic field can locally self-organize into complex braided structures serving defining the MBs of organisms, which would therefore be parts of much biffer organism. The flux tubes could connect living systems to each other and for instance, birds and fishes to their birth places.
- 2. The cyclotron time is much longer than for EEG rhythms and the natural guess is that the flux tubes of interstellar (galactic) magnetic field with field strength varying around the mean value $B_{gal} \sim 1$ nT are involved. The spectrum of cyclotron times would be of correct order of magnitude. $h_{gr} = h_{eff}$ hypothesis essential for the coupling of MB to biochemistry would be satisfied for $M = M_E$ in $h_{gr} = GMm/v_0$ so that one cannot assume that only dark mass contributes to the large mass in h_{qr} .

12.2.3 Trying to figure out the general mechanism

The details of the mechanism could be fixed by empirical input and using second assumption above as a guideline.

- 1. To my best understanding the role of RPM for avian chemical compass is speculative. RPM has been indeed observed only for magnetic fields stronger than 10 Gauss. Therefore it can be challenged. Even the notion of chemical compass is speculative.
- 2. The large cyclotron energies of dark charged particles would solve the problem caused by the extreme smallness of the electronic cyclotron energies this could be the case even for ions. Radical pairs and electron pairs assigned with them could of course be present also in TGD inspired model. Even pairs of ions and bosonic ions.
- 3. In TGD context one could assume only spin singlet or triplet Cooper pairs with large value of $h_{eff} = h_{gr}$ in $B_{end} = 0.2$ Gauss. The existence of superconducting phase would require that Cooper pairs assignable to several CRY molecules reside at same flux tube pairs. This would make the process quantum coherent in longer scale.

- 4. Quantum criticality is needed and could be associated with the emergence of high Tc superconductivity [K100, K101] and would correspond to the transversal oscillations of magnetic flux tubes analogous to phonons assumed in ordinary superconductivity and also in RPM. They would lead to a transitions between flux tube pair with shape of flattened square and pair of pairs flux tubes of similar shaped induced by reconnection somewhere along flux tube pair. In transition to superconductivity long flattened square would stabilize. Above transition temperature shorter flattened square shapes would be stable and one would have super-conductivity but in short scale only.
- 5. Electron pairs would be analogous to Cooper pairs and if there is many of them in the system one would speak of super-conductivity. In TGD inspired quantum biology the electron pairs might be Cooper pairs with members at flux tubes, which are either parallel or antiparallel. Spin singlet and triplet Cooper pairs would correspond to flux tubes with opposite and parallel fluxes. The quantum coherent fluctuation between them assumed in the model does not look possible in TGD framework and is not needed.
- 6. Spin singlet Cooper pairs would result for closed flux tubes with the shape of flattened square. If one has pairs of this kind of flux tubes in parallel and close enough to each other, the second member of the Cooper pair could hop to second flux tube of the other flux tube pair so that members of the pair would be at flux tubes with parallel magnetic fields and form triplet. This kind of hopping could gives rise to the coherent quantum transitions between spin singlet and triplets and the ratio of singlets and triplets would be different from one in the final state and depend on the value of magnetic field and cause a chemical effect. This assumption need not be necessary for the model to work. The control by MB could be much more direct and take place at bio-photon energies.
- 7. Dark photons are somehow emitted and go to the flux tubes of B_{gal} in the case of circadian rhythm and gravitaxis. In the case of avian navigation the flux tubes could be those of B_{end} (B_E could be equal to B_{end} inside brain) or those of B_{qal} .

The model of cell membrane as generalized Josephson junction with membrane proteins (channels and pumps) suggests a model in which the emission of dark photons could be generalized Josephson radiation with energy determined as difference of cyclotron energies plus ordinary Josephson energy. Dark Josephson photons going to the flux tubes of Earth equal to $B_{end} = 2B_E/5$ inside organism. from Blackman's experiments. This would give rise to magneto-detection of B_E . The mechanism would be exactly like the mechanism communicating sensory data to MB from cell membrane and allowing MB to control cell via genome using dark cyclotron photons. One can however consider also the replacement of B_{end} with B_{gal} .

One can imagine also the analog of RPM mechanism. In this case the dark electron pairs would fluctuate quantum coherently between spin singlet and triplet state and also interact with nuclear spins of the radical pair. The fusion of radical pair to a neutral state would destroy the quantum coherence. By a generalization of Uncertainty Principle cyclotron time would define the natural time scale and would be much longer than the time scale of coherence for RPM model. Maybe this could allow to test h_{eff} hypothesis.

12.2.4 More concrete model for the mechanism of magnetoreception and circadian rhythms

It is could to list some basic facts first.

- 1. Photopigment CRY must be excited by blue light needed to perceive magnetic field.
- 2. CRY interacts with magnetic field to establish the biorhythm.
- 3. External magnetic fields around 3 Gauss in presence of blue light slowed down the speed of the circadian clock.

What is the mechanism giving rise to the circadian clock? The naïve guess is that circadian rhythm corresponds to the periodic variation of the sensitivity to the external magnetic field determined by the amount of solar light. This certainly serves as a cue for the behavior and affects directly neuronal level but need not give rise to the fundamental biorhythm.

The simplest model does not explain why the circadian clock slows down (leading eventually to the loss of circadian rhythm) in external magnetic fields B_{ext} not too far from 3 Gauss- about 6 times the value of Earth's magnetic field? Hence it seems that the amount of blue light alone is not behind the clock mechanism but something more delicate is involved. The cyclotron frequencies assignable to weak external magnetic field (say B_{gal} whose flux tubes mediate gravitational interaction) as primary sources of circadian rhythms and controlled by B_{ext} somehow are suggested by the TGD inspired model of EEG.

The following picture suggests itself in TGD framework, where MB containing dark matter as large $h_{eff} = h_{gr}$ phases of ordinary matter controls biochemistry in quantum coherent manner in scales of even entire organism.

- 1. Basic entities are CRY molecule and its MB carrying some internal magnetic field B_{end} (to be not confused with $B_{end} \simeq .2$ Gauss) and having large h_{eff} . MB of galactic magnetic field B_{gal} : this in order to obtain cyclotron frequencies of order 24 hours for protons and ions. Magnetic flux tubes of galactic MB carrying cyclotron Bose-Einstein condensates for electrons, protons, ions each of them with $h_{eff} = h_{gr}$ proportional to the mass of charged particle in question. Different charged particles at their own flux tubes like books in the shelves of library.
- 2. Photons of blue light excite CRY. Excited CRY gradually returns to the ground state. This should lead to emission of dark cyclotron photons with cyclotron frequency of magnetic field involved for some charged particles at flux tubes? Transformation to dark cyclotron photons increasing hbar to $\hbar_{eff} = n \times \hbar$ takes place only at quantum criticality for the emitted photons. This might select the transitions corresponding to blue light.
- 3. The two MBs should interact by dark radiation at cyclotron frequencies. The excitations of CRY molecule by blue light would decay to ground state and emit dark photons with energy of blue light but with the cyclotron frequency for protons/ions of or order 24 hours. Magnetic field with the strength not too far from 1 nT, the strength of galactic magnetic field seems to be the most natural possibility.
- 4. CRY's MB must reconnect with that of galactic MB. Reconnection makes possible resonant interaction at multiples of cyclotron frequency. Large h_{eff} and biophoton hypothesis require that the energies involved are in visible-UV range. Blue light is in this range.
- 5. The resonant interaction would give rise to the perception of Earth's MB and make possible navigation: bird would fly to in the direction, where it perceives the flux tubes of Earth's MB.
- 6. Circadian rhythm would correspond to the galactic cyclotron frequency which would be same for all charged particles with the same charge by $h_{gr} = h_{eff}$ hypothesis implying that dark cyclotron photons have universal energy spectrum in the range of biophoton energies.

Why the external magnetic field with strength of order 3 Gauss has the slowing down effect? CRY should be able to couple to magnetic fields of this order of magnitude. The coupling should reduce the frequency of the emitted dark photons. It would seem that the frequency of dark photons emitted by CRY is reduced. This requires that the energy difference for its excited and ground states is reduced. If the ground state and excited state have different the difference of total energies contains the difference of cyclotron frequencies proportional to charge difference and magnetic field. If this difference is negative, its magnitude increases with B_{ext} so that the frequency of emitted photons reduced. Hence the CRY couples to flux tubes with weaker galactic magnetic field. This slows down the clock.

One can of course adopt a conservative attitude and consider a minimal modification of RPM by assuming quantum criticality and by replacing the Planck constant with $h_{eff} = n \times h$ eit $n \geq 50$. The excitation of CRY molecule responsible for the phenomena described could indeed

involve generation of radical pair in presence of blue light. The decay of RPM to neutral pair could produce photons transforming to dark photons at flux tubes? If so, the decoherence produced by the decay of RP would be compensated by coherence at the level of dark matter: negentropy maximization principle (NMP) [K80] would suggest this.

12.2.5 Gravitaxis and $h_{eff} = h_{qr}$ hypothesis

Gravitaxis might relate to the basic hypothesis about dark matter in TGD Universe as large h_{eff} phases: one would have $h_{eff} = h_{gr} = GMm/v_0$, v_0 is velocity parameter, m is some large mass, now presumably Earth's mass. This hypothesis is originally due to Nottale and plays key role in TGD inspired quantum biology.

What sensing a gradient in gravitational field could mean from the point of view of this hypothesis?

- 1. The simplest model assumes that the flux tubes along with gravitational interaction is mediated, are magnetic flux tubes with vanishing Kähler magnetic field but non-vanishing electromagnetic and Z^0 magnetic fields. These flux tubes would be vacuum extremals in absence of volume term in action. The volume term is proportional to cosmological constant and induced by the twistor lift of TGD [K57]. The flux tubes carrying magnetic monopole flux would be assigned to non-gravitational interactions: this distinction looks natural but does not seem to be necessary.
- 2. The density of the gravitational magnetic flux tubes must correlate with the average intensity of gravitational field at GRT limit of TGD. At fundamental level of many-sheeted space-time the detection of gravitational field strength would reduce to the detection of the density of these flux tubes. This detection would reduce to the same mechanism which makes possible magneto-sensitivity making possible avian navigation, biological clocks, and basic step of photosynthesis.

The overall conclusion is that TGD based quantum biology neatly unifies the description of several phenomena suggesting quantum biology in terms of magnetic body and dark matter as large h_{eff} phases. TGD based model is also needed since RPM proposal predicts effect which is at most 2 per cent of that needed to explain the observations.

12.3 TGD view about magneto-reception and circadian rhythm: few years later

Above is described the TGD based model for the findings related to magnetoreception and pacekeeper mechanism [L47] as it was for few years ago The model discussed also photo-taxis and gravi-taxis. The improved model discussed below relies on essentially the same elements but does not assume RPM as the mechanism producing nuclear spin polarization as an analog of compass.

12.3.1 Magneto-receptor as quantum compass

Magneto-reception could rely on quantum analog of compass consisting of flux tube containing dark cyclotron Bose-Einstein condensates. In the presence of external magnetic field - larger flux tube - Larmor radiation would be generated at cyclotron frequencies and energies scaled up by h_{eff}/h . These dark photons would transform to photons of blue light and be received by photo-receptors such as cryptochromes. The signal would be transformed to a chemical signal using the same basic mechanism as in photosynthesis without need to generate nuclear spin polarization. The same signal could also induce cyclotron transition of cyclotron Bose-Einstein condensates at magnetic flux tubes.

Why would blue light be needed?

1. The first explanation for the necessity of blue light could be that it kicks the cyclotron Bose-Einstein condensate from the ground state to excited state which them return to ground state by Larmor radiation. Blue light could induce transition between genuine transversal cyclotron degrees of freedom or between longitudinal "particle-in-box" degrees of freedom. One can however argue that also in ground state spin reversing transition are possible if the particle has magnetic moment (for Cooper pair this is not the case).

2. Second explanation would be that blue light serves as metabolic energy needed to increase the value of h_{eff} [L87, L111]. If one assumes $\hbar_{eff} = \hbar_{gr} = GMm/v_0$ it is not clear whether the increase of h_{eff} is possible at gravitational flux tubes. Should one assume that the increase of h_{gr} means increase of the mass m of charged particles attached (by wormhole contacts, that is touching) with the gravitational flux tubes? m could correspond to mass of electron or biologically important ion - an integer valued spectrum \hbar_{gr} in multiples of GMm_p/v_0 would result for ions.

12.3.2 The simplest pace-keeper mechanism does not explain the slowing down of the circadian rhythm

The simplest pace-keeper mechanism at fundamental level would correspond to a flux tube for which the orientation angle Θ of the external magnetic field with respect to the flux tube direction varies. Flux tube direction defines preferred quantization axis. The projection of the external magnetic field *B* to the direction of flux tube would vary and cause the cyclotron frequency scale to vary: one would have frequency modulation. The orthogonal component of *B* induces Larmor precession manifesting itself as cyclotron transitions at quantum level.

If there is a dark system with same value of h_{eff} receiving radiation with frequency near the cyclotron frequency, it develops a frequency resonance periodically if Θ varies periodically. Also the variation of the intensity of external magnetic field could be detected in this manner. Each resonance would correspond to a tick of the clock. The receiver could be also ordinary atom and in this case the tick would correspond to energy resonance. At magnetic side frequency resonance would be involved an at chemical side one would energy resonance.

What is important is that the period detected would directly correspond to the physical period.

There is however a problem involved. Why the irradiation by blue light would interfere with the pace-keeper mechanism? Why the clock would slow down and eventually cease to work?

- 1. Could the excitation of magnetic state make impossible the pace-keeper mechanism. If blue light increases the value of h_{eff} , energy resonance associated with the chemical aspect of pace-keeper function could be lost. The fraction of flux tubes for which this has happened would gradually increase during irradiation and this could spoil chemical pace-keeper mechanism.
- 2. But how to understand the slowing down of the clock? Why would the cyclotron period depending only the variation of external magnetic field increase? This is very difficult if not impossible to understand in a model assuming that the pace-maker rhythm equals to a rhythm assignable to the variation of external magnetic field if the measuring flux tube remains stationary.

12.3.3 A model based on cell membrane as a generalized Josephson junction (GJJ)

A more complex model could rely on cell membrane as GJJ [K103] [L4]. Now one would give up the simplest pace-maker mechanism and replace the bio-rhythm with generalized Josephson energy $E_{J,G}$ given as the sum $E_{J,G} = E_J + \Delta E_c(\hbar_{gr})$ of the ordinary Josephson energy $E_J = ZeV$ and the difference of cyclotron energies

$$\Delta E_c(h_{eff}) = \frac{\hbar_{eff}}{\hbar} \times \Delta E_c(\hbar) \tag{12.3.1}$$

associated with the flux tubes at the two sides of the membrane and orthogonal to it. Generalized Josephson frequency $f_{G,J}$ would be given by

$$f_{J,G} = \frac{\Delta E_{J,G}}{\hbar_{eff}} = \Delta E_c(h) + \frac{f_J}{h_{eff}} .$$
 (12.3.2)

1. The pace-maker rhythm could correspond to $f_{J,G}$ or its constant part coupling to dark flux tube by cyclotron resonance. This part should be rather slow (say 12 hours) and here one might consider specialized cells. In an analogy model as rotating gravitational pendulum $f_{J,G}$ would correspond to the rotation frequency Ω of the pendulum, perhaps near the critical value at which rotation transforms to oscillation. This transition could explain the loss of bio-rhythm. Irradiation by blue light should lead to a gradual reduction of Ω causing slowing down of the rotation. Same would happen also in the generation of nerve pulse.

Note that for the Josephson radiation received at flux tubes of dark magnetic body carrying galactic magnetic field - the model for pace-make rhythm already discussed would apply. This clock would tick when the modulated generalized Josephson period $T_{J,G}$ has the value T_{12} about 12 hours.

- 2. $f_J = ZeV/\hbar_{gr}$ would be reduced by irradiation by blue light feeding metabolic energy inducing a phase transition increasing \hbar_{gr} . The naïve expectation is that the difference Δf_c of cyclotron frequencies would correspond to the dominating part of Ω about $T_{12} \sim 12$ hours.
 - (a) For B_{end} option this turns out to be a good guess.
 - (b) For B_{gal} option the cyclotron frequency would correspond to a cyclotron period about T_{12} . In this case the two contributions to $f_{G,J}$ should of the same same order determined by $1/T_{12}$. The cyclotron contribution depends on the sign of $n_1 n_2$ so that Josephson and cyclotron contributions can have opposite signs and almost cancel: this could give rise to a period $T_{G,J} \ge T_{12}$. Negative sign might be needed to fine-tune $T_{J,G}$ to T_{12} . Note that Josephson contribution behaves like $1/\hbar_{gr}$ so that the effect of blue light could be understood. Note also that below a critical value of $T_{G,J}$ the rotation of analog gravitational pendulum changes to vibration and the clock-function is lost. This is indeed observed after long enough irradiation.
- 3. There is still one objection. The flux tubes associated with cell membrane Josephson junctions should have radius of order $L(151) \sim 10$ nm. For acceptable values of h_{gr} this would however give huge cyclotron energy scale of order keV. The only option seems to be that one has slightly different values of $B = B_i$, i = 1, 2, at the flux tubes at the opposite sides of membrane. One would have

$$n_1 B_1 = n_2 B_2 \tag{12.3.3}$$

in the ground state, where n_1 and n_2 are cyclotron quantum numbers so that the contribution of the difference of cyclotron energies to Josephson energy would vanish in ground state giving $E_{J,G} = ZeV/\hbar_{gr}$.

In the replacement $B_i \to B_i + B$ with $B = B_{end}$ or $B = B_{gal}$, the cyclotron energy difference becomes $\Delta E_J = (n_1 - n_2)\hbar_{gr}(M_D)eB/m$ or $(n_1 - n_2)\hbar_{gr}(M_E)eB_{gal}/m$, where one has $M_D = 2 \times 10^{-4}M_E$. One has

$$f_{G,J} = (n_1 - n_2)f_c(B) + \frac{ZeV}{h_{gr}}$$
, $M = M_D$ or $M = M_E$. (12.3.4)

4. If the charged particle has magnetic moment, the difference between cyclotron energies involves spin contribution proportional to $\mu(B_1 - B_2)/m = \hbar_{gr}\mu B_1(n_2 - n_1)/n_2$). This contribution is small if n_i is large and $n_2 - n_1$ is small. Second option is that magnetic moment μ vanishes: this is the case if one as Cooper pairs with vanishing spin.

The increase of \hbar_{gr} locally induced by metabolic energy feed could induce also nerve pulse [K103] [L4].

- 1. The ground state of axons would correspond to a propagating soliton sequence nano-scopically analogous to a sequence of rotational gravitational penduli with constant phase difference. The local increase of \hbar_{gr} would transform some rotating penduli to an oscillating mode and generate a local propagating perturbation identifiable as nerve pulse.
- 2. The increase of h_{gr} would correspond to a replacement of ions attached to gravitational flux tubes with heavier ones. This could relate to the flows of ions through cell membrane during nerve pulse. For instance, the replacement of electron with proton would reduce f_J by factor m_e/m_p . Nerve pulse would correspond to replacement of ions assignable to gravitational flux tubes with heavier ones.

12.3.4 Quantitative formulation of the model

Consider next the quantitative formulation of the model.

Basic parameters of the model

There are several parameters characterizing the new physics predicted by TGD and the model provides an excellent opportunity to get grasp on these parameters. In particular, the gravitational Planck constant $h_{gr} = GMm/V_0$ involves dark mass M and velocity parameter v_0 as parameters. The notion of magnetic field in TGD framework differs from its Maxwellian counterpart and magnetic field B_E of Earth can be decomposed to dark and ordinary part. Dark part consisting of monopole flux tubes could correspond to the endogenous magnetic field $B_{end} \simeq .2$ Gauss satisfying $B_{end} = 2B_E/5$ for $B_E = .5$ Gauss.

1. The parameters appearing in dark cyclotron energy

The condition $h_{eff} = h_{gr}$ would be satisfied. $\hbar_{gr} = GMm/v_0$ contains 3 parameters.

- 1. M denotes the dark mass expected to differ from M_E . There are several estimates for M.
 - (a) $M = M_D = 2 \times 10^4$ was suggested by the model of fountain effect in super-fluidity [?]. While writing this article I learned that the "inner inner" core of Earth has mass $M_D/2 = 10^{-4}M_E$ if its density is the average density of Sun. The density of the inner core is certainly higher.
 - (b) I have associated to Earth also a spherical layer with mass $M = .5 \times 10^{-4} M_E$ at distance of Moon. This mass has effect only at distances larger than distance of Moon but if one accepts the notion of magnetic body the effect could be real.
- 2. One can ask whether also the masses of various parts of Sun such as the mass of inner core with mass of inner inner core subtracted, mass of outer core, and mass of entire Sun could define dark masses with different value of v_0 . Also sums of the masses could be involved. It turns out that the model requires masses $M = M_D$ for detection of B_{end} and $M = M_E$ for pace-keeper mode as dark masses. In the model of Nottale for planets as analogs of Bohr orbits one has $M = M_{Sun}$ [E1] [K117, K93, K95].
- 3. For the 4 inner planets of Sun one has $\beta_0 = v_0/c \simeq 2^{-11}$ and $\beta_0 = 2^{-11}/5$ for outer planets: $\beta_0 = 2^{-11}$ is the first guess also for Earth to be taken very cautiously. The value of β_0 could depend on the M_D but also a restricted universality can be considere. I have considered a model for β_0 [L81] [K18].

2. Strenghts of the magnetic fields

In TGD Universe Earth's magnetic field contains a monopole flux tube part - perhaps identifiable as the endogenous magnetic field $B_{end} = 2B_E/5$ - and non-monopole part.

1. B_E or part of it is measured. B_E has two parts in TGD Universe. Monopole part and non-monopole part. $B_{end} = 2B_E/5 = .2$ Gauss is suggested by the findings of Blackman and others and could corresponds to the monopole flux part of B_E . The nominal value of the Earth's magnetic field $B_E = .5$ Gauss.

2. B_{end} corresponds to a flux tube radius of about L(169) then the minimal radius for flux tube would be about $L(163) \sim .640$ nm. The energies would be of the order of energies defined by membrane potential V. This looks natural at least because axonal radius is of order micrometer so that flux tubes with roughly half of the axonal radius could make sense.

Monopole flux tube with a stronger magnetic field detecting B_E or B_{end} would be naturally associated with the magneto-receptor. This flux tube should has naturally radius 5 nm or 10 nm corresponding to L(k), k = 147 or k = 151.

3. The estimate for the value of B_{gal} assigned with the pace-keeper mechanism is in the range .5 - 1.9 nT. For $B_{gal} = .5$ nT one has $B_{gal} = 2.5 \times 10^{-5} B_{end}$.

Remark: Could either monopole or non-monopole part be parallel to rotation axis of Earth? Non-monopole part would be naturally parallel to rotation axis since it is generated by the rotation of outer core. Monopole part could correspond to the magnetic axis. The change of the direction of B_E would be induced by the change of the direction of the monopole part and induce currents changing the non-monopole part. Monopole part together with this refreshing mechanism would explain the maintenance B_E [L40]. The magnetic North pole is recently moving rather rapidly towards Siberia and the strength of B_E has been decreasing suggesting that the refreshing operation has been activated.

Quantitative tests

Does the proposed picture work quantitatively? Or is even the qualitative model correct as such.

- 1. The values of the velocity parameters
- 1. Just as a blind guess I assumed first $\beta_0 \simeq 2^{-11}$ assigned to the 4 inner planets of Sun by Nottale [E1] [K117, ?] (the assignment was based on the idea about near universality of β_0) and to the identification of dark mass as $M = M_D = 2 \times 10^{-4} M_E$ - the mass estimate for the "inner inner" core. This assignment gave a reasonable value for the universal cyclotron energy scale.
- 2. A possible justification for the guess comes from the behavior of the rotation velocity of particle in gravitational field of Earth behaving as $v = \sqrt{GMr}$ for circular orbit of radius r. At the surface of Earth with r = R the rotational velocity of Earth

$$\beta_{0,E} \simeq \beta_{rot,R} 1.5 \times 10^{-6} = 3 \times 10^{-3} \beta_{0,Sun} \tag{12.3.5}$$

would be first order of magnitude guess.

3. At the radius r = 300 km assignable to "inner inner" core one would have by scaling

$$\beta_{0,D} = \sqrt{R_E} r \times 2\beta_{0,E} \simeq 0.8 \times \beta_0 \quad . \tag{12.3.6}$$

This is surprisingly near to β_0 , which suggests that this parameter might be universal. One can test this hypothesis by looking what one obtains from this ansatz for the pace-maker model with $M = M_E$ and it turns out that nearly same value of β is needed.

4. One must bear in mind that also the value $\beta_{0,D} = \beta_0 = 2^{-11}$ is number theoretical favoured. **Remark**: The model for stars as analogs of blackhole like objects [L99] supports the view that the spectrum of β_0 comes in powers of 2 and corresponds to the spectrum of preferred p-adic length scales.

2. Cyclotron and Josephson energy scales and corresponding frequencies

Cyclotron and Josephson energy/frequency scales will be considered for three cases.

• Magneto-receptor mode

$$(B_{end}, M_D = 2 \times 10^{-4} M_E, \beta_{0,D} = \beta_0)$$
 , .

• First variant of pace-keeper mode

$$(B_{gal}, M_E, \beta_{0,E})$$
,

where $\beta_{0,E} \simeq 3 \times 10^{-3} \beta_0$ is the rotational velocity at the surface of Earth.

• Second variant of pace-keeper mode

$$(B_{qal}, M_E, \beta_0)$$

Universal cyclotron energy is given as a multiple $E_n = nE_c$, $E_c = ZeB/m_{eff}$. For $h_{eff} = h_{gr}$ cyclotron energies are universal having no dependence on the mass of the charged particle. The interpretation is in terms of Equivalence Principle. One has

$$E_c = \hbar \frac{ZeB}{m_{eff}} \quad , \tag{12.3.7}$$

where one has

$$m_{eff} = \frac{\hbar\beta_{0,D}}{GM_D} = \frac{2\hbar\beta_{0,D}}{r_S} = \beta_{0,D} \times 1.24 \ eV \ . \tag{12.3.8}$$

Note that this value is for $M_D = 2 \times 10^{-4} M_E$. For $M_D \to M_E m_{eff}$ scales to $m_{eff} = .5 \times 10^{-4} m_{eff} = \beta_{0,D} \times 2.48 \times 10^{-4}$ eV for $M_D \to M_E$ applying for B_{gal} .

1. For $(B_{end}, M = M_D, \beta_{0,D} = \beta_0 = 2^{-11})$ mode this gives the estimate

$$E_c \simeq 2 \ eV$$
 ,

Note that E_c scale is considerably higher than E_J scale about .06 eV in magneto-receptor mode. One has $f_J/f_c = E_J/E_c = .03$.

Cyclotron frequencies of biologically important ions in B_{end} are in EEG range 1-100 Hz (DNA has on the average $f_c = 1$ Hz). One has for $f_c(e, p, Fe^{++}) = (6 \times 10^5, 300, 10)$ Hz and $f_J(e, p, Fe^{++}) = (18 \times 10^3, 9, .3)$ Hz.

2. For $(B_{gal}, M = M_E, \beta_{0,E} = 3 \times 10^{-3} \beta_0$ mode one has $E_c = .13$ eV, which is above thermal threshold and roughly the energy 2eV of Cooper pair for cell membrane with voltage .06eV. One has $f_J/f_c = E_J/E_c \simeq .06/.13 \simeq .46 \le 1$ and $T_J/T_c \simeq 2.2$.

This option looks rather reasonable. In particular the effect of blue light increases \hbar_{gr} and reduces f_J slowing down the circadian rhythm and can also cause the transition in which the $f_{G,J}$ becomes critical and the rotation of the analog pendulum transforms to oscillation and circadian rhythm is lost.

3. For $(B_{gal}, M = M_E, \beta_0)$ mode one would obtain

$$E_c = 4 \times 10^{-4} \ eV$$

which is below thermal threshold. $E_{G,J}$ would be however above thermal threshold. One has $f_J/f_c = E_J/E_c \simeq 150$ and $T_J/T_c = 1/150$. This option is not attractive.

A comment about the special role of DNA molecules is in order. DNA molecules are charged carrying charge of -1 units per nucleotide and -2 units per nucleotide pair of double strand.

- 1. For B_{end} the cyclotron frequency of DNA nucleotide would be about 1 Hz on the average and for fixed h_{eff} would not depend much on the length of DNA since DNA has constant Z/m ratio. Also cyclotron energy would be constant for fixed h_{eff} . For single nucleotide the cyclotron frequency would be same as for any ion for $B_{gal} = .5$ nT and equal to $f_c = 4 \times 10^4$ s to be compared to $T_{12} = 4.3 \times 10^4$ s.
- 2. For $h \to h_{gr}$ the situation changes. $f_{J,G}$ would behave like a + b/N, N the number of nucleotides. $E_{J,G}$ would behave like aN + b

Trying to build a more general view

The proposed picture is rather general and there is a temptation to generalize it further. The question whether there might be other dark masses besides M_E and M_D perhaps assignable to structures of Earth was already briefly considered. One can also ask about the spectrum of magnetic fields and whether also other structures bounded by double membrane (as a matter of fact, also single layered membrane might allow GJJs) could be possible.

1. What about p-adically scaled variants of magnetic fields?

The model discussed involves only 2 magnetic fields: B_{end} and B_{gal} , and one can expect that also other magnetic field strengths might be important. p-Adic length scale hypothesis suggests scale hierarchy of magnetic field strengths.

 B_{end} corresponds to k = 169 defining p-adic length scale $L(169) = 5 \ \mu m$. This size scale is by factor 2 longer than the scale L(167) assignable with cell nucleus. DNA is coiled and there is temptation to assign with the coiling the Gaussian Mersenne primes $M_{G,k} = 2^k - 1$. k = 151, 157, 163, 167: the existence of this Gaussian Mersennes is a number-theoretical miracle. Magnetic fields

The natural scaling for B_{end} assignable to the flux tubes with radius L(k) would be $B_{end}(k) = 2^{169-k}B_{end}$. cyclotron frequencies for B_{end} correspond to cyclotron frequencies in the EEG and the additional p-adic length scales would give rise to scaled up variants of EEG possibly assignable to these smaller structures. Also larger flux tubes can be considered. $B_{gal} \simeq B_{end}(185)$ would also give rise to the counterpart of EEG which scaled up variants of resonance frequencies

$$f_{G,J} = 2^{169-k} f_c(ion, B_{end}) + f_J(\hbar) \frac{\hbar}{h_{gr}} \quad . \tag{12.3.9}$$

Could different values of B_{end} correspond to different modes for GJJ and cell? For $B_{end}(169)$ $f_{J,G}$ corresponds to EEG spectrum assigned to vertebrates having nervous system and nerve pulse activity having in TGD framework interpretation as manner to connect flux tubes assignable to axons to communication channels along which dark photons can propagate and mediate the message. Nerve pulse patterns would also generate generalized Josephson radiation communicating information to MB.

Could $B_{end}(k)$, $k \leq 169$, correspond to scaled up variants of EEG spectrum assignable to invertebrates? In this case the nerve pulse propagation would be missing but Josephson but localized analogs of nerve pulses involving the transformation of rotational motion to vibrational motion for the pendulum analog of Josephson junction would be possible.

2. Music and magnetic fields

The assumption that the values of B_{end} come in octaves is of course too strong. TGD based model for hearing and music experience [K102] leads to the proposal that the notes of scale correspond to cyclotron frequencies assignable to specific values of B_{end} and that each p-adic length scale would define its own octave.

Specific note of the scale identifiable as a rational multiple $f = rf_0$, $1 \le r \le 2$, of the fundamental frequency f_0 of the octave would correspond to a specific strength $B_{end}(r,k)$. This assumption is reasonable since in the adelic vision [L75] rationals correspond to the lowest evolutionary level. For GJJ the formula for $B_{end}(r)$ characterizing the note rf_0 associated with rational $1 \le r = p/q \le 2$ would be $fG, J = rf_0 = \frac{1}{m_{eff}} ZeB_{end}(r) + f_J(\hbar_{gr})$ giving

$$eB_{end}(r) = \frac{m_{eff}}{Z} \times (rf_0 - f_J[\hbar) \frac{m_{eff}}{m}] , \quad m_{eff} = \frac{\hbar v_0}{GM} = \frac{2\hbar v_0}{r_s} .$$
 (12.3.10)

The appearance of Schwartschild radius in formula relate to music is not something that one might expect! Note that $m \propto A$ holds true for ions. The condition $f_0 \geq f_J(\hbar) \frac{m_{eff}}{m}$ seems necessary.

3. Other membrane bounded structures

Quite generally, bio-structures with sizes between cell membrane thickness and cell size could be characterized by the scales L(k), $k \in \{151, 157, 163, 167\}$ equal to [10, 80, 640, 2500] nm. Could there exist besides cell and nuclear membrane also other membrane structures giving rise to GJJs?

Most viruses have radius varying from 10 to 125-200 nm and could correspond to k = 151, 157and possibly other values of $k \in \{151, 159\}$. The largest viruses have radius 250 nm and length about 350-500 nm. Filoviruses have diameter about 80 nm (radius would correspond to L(155)) and length of 1400 nm. Viruses are contained by capsides consisting of identical proteins and can have lipid envelope derived from the host membrane. Maybe viruses utilize the GJJs of the host membrane.

Chloroplasts (http://tinyurl.com/ycthk562) and mitochondria (http://tinyurl.com/ oh5qrob) are structures surrounded by double cell membrane: the inter-membrane space (http: //tinyurl.com/ums7uyx) is 10-20 nm thick suggesting total thickness 20-30 nm. This could correspond to L(152). Could chloroplasts and mitochondria define GJJs in scale L(152).

Remark: Nucleolus (see http://tinyurl.com/yavahwzt) inside cell nucleus has diameter 2.5 μ m corresponding to L(167) but is not surrounded by membrane. It is however possible that flux tubes of $B_{end}(167)$ accompany it.

Endoplasmic reticulum (ER) (http://tinyurl.com/ybjmjykb) is 2-layered structure with thickness of cell size scale.

- 1. The layers have thickness 2 μ m and having 1 μ m empty region between. The total thickness is 5 μ m, which corresponds to L(169) assignable to B_{end} . One of the first proposals inspired by p-adic length scale hypothesis in biology was that ER could give rise to the analog of cell membrane. This structure would be naturally accompanied by flux sheet of $B_{end}(169) \equiv B_{end}$ (cell membrane would be accompanied by cylindrical flux sheet of $B_{end}(169) \equiv B_{end}$).
- 2. Could one assign transversal flux tubes of thickness L(169) with ER possibly measuring the value of magnetic field. Could the measured magnetic field be $B_{end}(169)$ associated with the flux sheet? This would allow to get rid of the condition $n_1B_1 = n_2B_2$ for the magnetic fields at the two sides of cell membrane with order of magnitude $B_{end}(151)$. The problem is that intuitively compass needle should carry magnetic field stronger than the detected field.
- 3. B_{gal} is a more natural candidate for the magnetic field detected by ER. B_{gal} would correspond to rather slow cyclotron rhythms. The cyclotron frequency for electron would be scaled down by B_{gal}/B_{end} from 6×10^5 Hz to 15 Hz. ER would live slow life as compared to cell membranes - maybe it corresponds to our conscious life.
- 4. Interestingly, the experiments of Blackman [J23] and others involved irradiation of vertebrate brain with harmonics of 15 Hz frequency. The explanation of the findings in terms of cyclotron radiation led to the identification in terms of cyclotron frequencies of Ca⁺⁺ ion in $B_{end} = .2$ Gauss. Could there be a communication between these two levels at the cyclotron frequencies of Ca⁺⁺? The communication could take place by GJR emitted by dark electron Cooper pairs at endoplasmic reticulum and absorbed GJJs of cell membranes carrying $B_{end}(151)$. Could this explain the very special role of Ca⁺⁺ ions in biology (see http://tinyurl.com/ w9o29xa)?

The objection is that the dark photon energies are different for B_{end} and B_{gal} : ~ 2 eV and about ~ .1 eV respectively. Energy conservation allows the decay of dark B_{end} photon to a bunch of about 20 dark B_{gal} photons, which are identical. ZEO allows the time reversal of this process. The bunch of identical 20 dark photons is analogous to a Bose-Einstein condensate behaving like single particle so that one has effectively 2-vertex also now in accordance with the hypothesis that all transformations changing h_{eff} occur at single particle level. I have indeed proposed two processes changing the value of h_{eff} : decaying to a BE condensate would preserve frequency but not energy for single quantum and transformation of say dark photon to bio-photon would preserve energy but not frequency.

12.4 Appendix: What TGD is?

Since the purpose is to see the representations through TGD lense it is polite to first to tell to the reader what TGD is. The reader interested in details can find them for instance in [K146].

12.4.1 Why TGD?

The first question is "Why TGD?". The attempt to answer this question requires overall view about the recent state of theoretical physics.

Obviously standard physics plagued by some problems. These problems are deeply rooted in basic philosophical - one might even say ideological - assumptions which boil down to -isms like reductionism, materialism, determinism, and locality.

Thermodynamics, special relativity, and general relativity involve also postulates, which can be questioned. In thermodynamics second law in its recent form and the assumption about fixed arrow of thermodynamical time can be questions since it is hard to understand biological evolution in this framework. Clearly, the relationship between the geometric time of physics and experienced time is poorly understood. In general relativity the beautiful symmetries of special relativity are in principle lost and by Noether's theorem this means also the loss of classical conservation laws, even the definitions of energy and momentum are in principle lost. In quantum physics the basic problem is that the non-determinism of quantum measurement theory is in conflict with the determinism of Schrödinger equation.

Standard model is believed to summarize the recent understanding of physics. The attempts to extrapolate physics beyond standard model are based on naïve length scale reductionism and have products Grand Unified Theories (GUTs), supersymmetric gauge theories (SUSYs). The attempts to include gravitation under same theoretical umbrella with electroweak and strong interactions has led to super-string models and M-theory. These programs have not been successful, and the recent dead end culminating in the landscape problem of super string theories and Mtheory could have its origins in the basic ontological assumptions about the nature of space-time and quantum.

12.4.2 TGD and GRT

The new view about space-time as 4-D surface in certain fixed 8-D space-time is the starting point motivated by the above mentioned energy problem of general relativity and means in certain sense fusion of the basic ideas of special and general relativities.

The higher-dimensional space-time is 8-D $H = M^4 \times CP_2$: empty Minkowski space M^4 of special relativity with points replaced by 4-D CP_2 (complex projective space of 4 real dimensions). The symmetries of special relativity are preserved but lifted to the level of H so that classical conserved quantities like energy exist. CP_2 in turns codes in its geometry the standard model symmetries and quantum numbers and its spinor connection codes for classical electroweak gauge fields. Their projections to space-time surface are dynamical. Also classical color fields can be understood. These geometrized fields are expressible only in terms of four CP_2 coordinates and cannot as such directly correspond to those of standard model. How standard model emerges as a limit of TGD will discussed below.

Rather recently [K57] I have discussed twistor lift of TGD replacing space-times with the twistor spaces and H with the product of twistor spaces of M^4 and CP_2 , which are unique as 4-D spaces in the sense that they have twistor spaces with Kähler structure making possible to lift the Kähler action to 6-D one. The theory dimensionally reduced to a 4-D theory containing cosmological constant and gravitational constant as additional constants besides CP_2 radius and Kähler coupling strength.

12.4.3 TGD and string models

TGD can be also seen as a generaralization of hadronic string model or of superstring models by replacing strings with 3-D surfaces and 10-D space-time with 8-D $M^4 \times CP_2$. 3-space as we experience it corresponds to a large 3-surface to which smaller 3-surfaces are glued by wormhole contacts. These smaller 3-surfaces we would interpret as physical objects with shape and size and when they are really small, we call them elementary particles. We would directly see this extremely complex space-time geometry. This geometry has fractal hierarchical structure: 3-surfaces glued to larger 3-surfaces glued to....

As a matter fact, string world sheets and what I call partonic 2-surfaces in 4-D space-time regarded as space-time surface turn out to be fundamental objects of also TGD forced by very general principles such as well-definedness of em charge and strong form of holography (SH) implied by strong form of general coordinate invariance [K144]. SH states that information given at these 2-surfaces allows to deduce information about quantum states and classical dynamics: effective 2-dimensionality in the sense of information theory would be in question.

12.4.4 TGD based ontology

TGD forces to dramatically generalize the ontology of standard model and GRT.

1. The new view about space-time differs radically from that of GRT. Space-time surfaces are topologically non-trivial in all scales. They have typically finite size and obey size scale hierarchy. One can glue space-time sheets to larger space-time sheets to get a fractal scale hierarchy with sheets glued to larger sheets by wormhole contacts and having interpretation as correates for physical objects.

Second key difference is that space-time surfaces can have also regions with Euclidian signature of the induced metric - time and space are geometrically in the same role. Wormhole contacts are this kind of regions and serve as building bricks of elementary particles and are identifiable as lines of generalized scattering diagrams.

- 2. A new view about classical fields emerges distinguishing TGD from Maxwell's theory. One can say that each physical object has field identity field body consisting of space-time sheets. The notion of magnetic body (MB) turns out to be central in TGD inspired biology and adds MB to the pair organism-environment as a third member. The communications from BB involve classical radiation fields: EEG is one example of this communication from the brain to the MB of brain. The size scale of MB is typically considerably larger than that of BB: even of order Earth size scale or even larger. MB makes possible remote mental interactions and could be behind the morphic fields of Sheldrake.
- 3. How TGD relates to GRT and standard model? The basic idea is that the sheets of manysheeted space-time obeying extremely simple physics (only 4 analogs of field variables plus SH realized by preferred extremal property implying effective 2-dimensionality of dynamics) are lumped together and identified as GRT space-time differing slightly from flat M^4 .

The deviation comes in the following manner. The deviations of the induced metric for spacetime sheets from M^4 metric (empty space metric) are summed up to give GRT gravitational field as deviation from M^4 metric. Induced gauge potentials known once space-time surface is known are summed up in the same manner to give the gauge potentials of standard model. This because test particle experiences the sums of various induced fields associated with space-time sheets. Ordinary linear superposition is replaced at fundamental level with the set theoretic union for space-time sheets.

4. The hierarchy of Planck constants $h_{eff} = n \times h$ was originally motivated by certain strange findings in neuroscience about effects of ELF em fields on vertebrate brain [K99, K98]. First it was postulated that dark matter corresponds to phases of ordinary matter with $h_{eff} = n \times h$ having certain special kind of space-time surfaces (singular *n*-sheeted covering spaces) as correlates. Later it turned that these phases are actually predicted by basic TGD: in TGD framework Planck constants is for single space-time sheet *h* and only effectively $h_{eff} = n \times h$ but at QFT limit one can say that $h_{eff} = n \times h$ is strictly true. Later the view about dark matter as evolved and according to the recent view dark matter would emerge at quantum criticality (perhaps even at ordinary criticality) and would be a correlate for long range quantum fluctuations and long range quantum coherence. Various quantal length scales are indeed typically scaled up by n. This suggests that biosystems are quantum coherent and quantum critical because MB contains dark matter.

MB containing dark matter would serve as intentional agent receiving sensory data from BB and controlling BB. EEG and its generalizations to various frequency ranges based on dark photons would be the tool for this. The dark cyclotron photons assignable to given charged particle would have very specific value of h_{eff} guaranteeing that cyclotron energy scale does not depend on particle mass and would be in the range of biophoton energies (visible and UV). Biophotons would result in the phase transition $h_{eff} \rightarrow h$. Also dark photons in IR range (Josephson photons assignable to cell membranes) are predicted.

Biochemistry would not be enough to understand the biology. MB and its "motor actions" would be crucial for understandind bio-catalysis, in particular the miraculous property of biomolecules to find each other in the molecular crowd.

5. Zero energy ontology (ZEO) is a further new piece of TGD ontology. In standard ontology the state of system at fixed value of time characterize the time evolution of the system. Classically the state is typically characterized by particle positions and velocities and by values of say Maxwellian fields and their time derivatives. Field equations in principle allow to deduce the time evolution from these.

In ZEO one introduces causal diamond (CD). CD is intersection of future and past directed light-cones (Penrose diagram) with points replaced by CP_2 . CDs are assumed to form a fractal scale hierarchy. CD has two light-like boundaries: "future" and "past" boundary. Light-likeness means that 3-D M^4 projection of given boundary correspond to a sphere expanding with light-velocity.

Physical states are replaced with zero energy states analogous to physical events consisting of initial and final states. Initial/final state can be assigned to 3-D intersections of spacetime surfaces with the "future"/"past" boundary of CD. ZEO is consistent with the crossing symmetry of quantum field theories and with the conservation laws. It is however extremely flexible since any zero energy state is in principle achievable by a sequence of quantum jumps. The analog of ordinary positive energy can be assigned with either "future" or "past" boundary and the arrow of time is different for these states. ZEO leads to a quantum measurement theory allowing to circuventn the basic problem of standard quantum measurement theory due to the non-determinism of state function reduction contra determinism of unitary time evolution.

6. p-Adic and adelic physics are further new ontological elements of TGD. p-Adic numbers are generalizations of real numbers, and there are infinite number of p-adic number fields for each prime p = 2, 3, 5, ... I ended up with p-adic physics almost accidently by playing with p-adic generalization of thermodynamics and finding that p-adic thermodynamics can reproduce elementary particle masses with minimal assumptions and thus replaced Higgs mechanism with more fundamental theory. The properties of p-adic number led soon to the proposal that p-adic number fields are correlates for cognition and imagination. Much later this led to the unification of real physics and various p-adic physics in terms of adelic physics fusing all these number fields to a bigger structure.

Why p-adic physics is so nice that one can talk about p-adic embedding space and space-time surfaces as kind of cognitive representations of real space-time surfaces. In particular, SH allows to assign p-adic space-time surface to given set of string world sheets and partonic 2-surfaces as preferred extremal but no necessary to real one. All imaginations cannot be realized!

Also p-adic generalization of Shannon entropy makes sense but it can be negative. One can say that entanglement carries negative p-adic entropy - positive negentropy - although real entropy is non-negative. The interpretation is in terms of conscious information naturally assignable to cognition.

12.4.5 TGD, quantum measurement theory, and consciousness

TGD inspired theory of consciousness can be seen as quantum measurement theory in ZEO. Observer as an outsider becomes a part of physical system. Observer does not cause state function reductions but as a concious entity is a sequence of state functions on same boundary of CD - generalized Zeno effect.

- 1. The maximization of negentropy gain in state function reduction becomes the basic variational principle of consciousness theory consistent with second law which applies at the level of ensembles and is closely related to the growth of real entanglement entropy. I refer to this principle as Negentropy Maximization Principle (NMP).
- 2. In ZEO state function reduction can take place to either boundary of CD. In a sequence of reductions to a fixed boundary the boundary itself remains fixed as also the states at it possibly entangled with those at the opposite boundary. This boundary is referred to as "passive". The second "active" boundary drifts farther away from the passive boundary and the states at it change. Each step can be regarded as time localization localizing the active boundary of CD.

Self corresponds to this sequence of state function reductions. The permanent part of self - "soul" - corresponds to the unchanging part of self and changing part corresponds to consciousness determined byt sensory input. In particular, the experience about flow of time corresponds to the drift of the active boundary of CD farther away. Self is a generalized Zeno effect.

3. Eventually NMP forces the first reduction to the opposite boundary to occur. This is the counterpart of the usual large and non-deterministic quantum jump assignable to quantum measurement. Self dies and re-incarnates as time reversed self since the CD starts to increase in size in opposite time direction. This prediction has rather radical implications.

Some of the implications deserve to be noticed.

- 1. One ends up with a new view about time. Geometric time as fourth space-time coordinate (or time coordinate as distance between the tips of CD) is not same as subjective time defined by a sequence of state function reductions. The consciousness experience associated with each reduction has the changing components with contents coming from the active boundary so that subjective time is mapped to discrete clock time.
- 2. Selves having hierarchy of CDs as embedding space correlate form a hierarchy. Subself is assumed to be experienced as mental image and subsubselves as kind of average sub-subself so that self is not drowned to microscopic information. Subconscious corresponds to conscious sub-sub-... -selves. We are ourselves mental images of some higher level self and the hierarchy continues ad infinitum with entire Universe at the top.

Chapter 13

The anomalies in rotating magnetic systems as a key to the understanding of morphogenesis?

13.1 Introduction

During almost two decades I have returned repeatedly to the fascinating but unfortunately unrecognized work of Roschin and Godin about rotating magnetic systems [H17]. The motivation has been that the strange effects such as change of weight proportional to the rotation velocity of rollers taking place above 3.3 Hz rotation frequency and rapid acceleration above 9.2 Hz up to frequency 10 Hz could provide the clues for developing a general vision about morphogenesis of magnetic body, whose flux quanta carry Bose-Einstein condensates of dark charged ions with given mass and charge if the hypothesis $h_{eff} = h_{gr}$ holds true.

At this time my friend Samuli Pentikäinen re-stimulated my interest by sending some links to the files describing the patent of Godin and Roschin. We had a nice brain storming about the system, which eventually inspired the preparation of this article to clarify my recent views about the system. One can find from web a brief description of the rotating magnetic system (see http://tinyurl.com/jceswe4) and the english translation of the patent (see http://tinyurl.com/hb6bfla). I am grateful for Samuli for these links and interesting discussions. In the sequel I summarize the most recent views. It is earlier view but with some important new ideas added.

The best way to proceed is to identify the crucial questions. In the following I list these questions. I have proposed several alternative answers to these questions and the goal in the following is to fix the answers as uniquely as possible.

Consider first questions related to the formation of magnetic walls.

1. How could the observed magnetic walls be formed? So called Chladni mechanism making visible the nodal lines of oscillations of a vibrating square plate by putting thin powder on the plate so that the powder ends up to the nodal lines is neatly described in the article of Geesink [I99] (see http://tinyurl.com/j9rsyqd).

Could a generalization of Chladni mechanism [L60] explain the formation of magnetic walls as an analog of morphogenesis at the level of dark matter?

Neither standing waves nor circularly polarized waves are possible as single sheeted structures. Propagating circularly polarized waves with net spin assignable to pairs of "topological light rays" ("massless extremals", MEs) and standing waves assignable to the pairs of these pairs would have cylindrical nodal surfaces, which in the simplest situation would be stationary.

Charged flux tubes would drift to these stationary 2-D magnetic walls where electric field vanishes. Ordinary matter would in turn condense around magnetic body as assumed in TGD inspired quantum biology so that dark morphogenesis would induced ordinary morphogenesis.

2. Could the generation of magnetic walls be a quantum phase transition taking place at quantum criticality? Could generalized Chladni effect lead to the drift of the charged flux tubes

to the nodal surfaces defining the magnetic walls? What could serve as the seed of this phase transition? Since the signs of the momentum gain and acceleration at the roller correlate with the rotation direction, the rotation of roller and its magnetic body could serve as the seed.

What can one say about magnetic flux tubes and walls?

- 1. Could the flux tubes from rollers go through wormhole contacts to a larger space-time sheet containing return flux tubes from rollers drifting to the magnetic walls?
- 2. The magnetic walls have magnetic field in the same direction as the magnetic field of rollers in the same region so that the interpretation as return flux makes sense. The patent does not tell whether the magnetizations are parallel or not. If the magnetizations are opposite as stability considerations would suggest, the return flux for the magnetic flux from stator would not form magnetic walls. If so, the rotation of the rollers should be essential for the formation of the magnetic walls and would serve as a seed of this phase transition.

Where does the dark matter at magnetic walls come from?

- 1. The charge density $n = \omega B/e$ (c = 1) at roller changing sign with the direction of rotation would be naturally due to the transfer of electrons between rollers and magnetic body and one can interpreted the distance between magnetic walls as cyclotron frequency associated with electrons in the magnetic field B = .3 Tesla. The density of electrons (holes) is extremely small and cannot explain weight change and spontaneous acceleration. Neither can the electrons from rollers correspond to the dark matter at the flux tubes and magnetic walls.
- 2. Could the charged particles already exist at the flux tubes leaving the roller and at the return flux tubes and drift to the flux walls? Does $h_{gr} = h_{eff} = n \times h$ hypothesis [L47] [K95, ?] guaranteeing that given flux quantum contains only charged particles of given mass hold true? This allows in principle many kinds of charged particles. In TGD inspired quantum biology many ions indeed appear and dark phases.

Note: The notion of gravitational Planck constant h_{gr} introduced originally by Nottale deserves a comment. It is defined as $\hbar_{gr} = GMm/v_0$, where M could in the recent case be $M_D \sim 10^{-4}M_E$ for flux tubes of $B_{end} = 2B_E/5$ and Earth's mass M_E for the flux tubes of galactic magnetic field $B_{gal} \sim 1$ nT mediating the gravitational interaction of Earth. By assuming that the parameter $r = v_0/v_{rot,M}$ for Earth has the same value as for Sun. The value of r is fixed by $v_0 \simeq 2^{-11}$ for Sun from the Bohr orbit model for the orbits of inner planets originally proposed by Nottale [E1] [K117] and v_{rot} is the rotational velocity of Sun.

3. Is there a connection with biology? The spontaneous acceleration occurs in the range 9.2-10 Hz. This range corresponds to alpha band in EEG. In TGD inspired biology the endogenous magnetic field $B_{end} = .2$ Gauss (maybe Earth's magnetic field inside organism or at some distance from the surface of Earth) and magnetic field with strength range around the average value $B_{qal} \simeq 1$ nT of galactic magnetic field are important.

Are these magnetic fields involved and could they serve as sources of dark charged particles? The flux tubes mediating the gravitational interaction of Earth could be at the flux tubes which are originally those of galactic magnetic field and would satisfy the condition $h_{eff} = h_{gr}$ guaranteeing that dark cyclotron photons have the energy spectrum of bio-photons as a universal energy spectrum in visible-UV range in which also the transition energies of bio-molecules are.

Could the rotation of the rollers inducing the rotation of flux tubes increase the probability of reconnections with the flux tubes of $B_{end} = .2$ Gauss and $G_{gal} \sim 1$ nT mediating Earth's gravitational interaction? Could the charged particle condensates from these flux tubes flow to the flux tubes of rollers or to the magnetic walls? The values of critical frequencies indeed suggests that $B_{end} = .2$ Gauss and $G_{gal} \sim 1$ nT could have an important role.

A further group of questions relates to the mechanism of effective weight change and spontaneous acceleration.

- 1. Where do the momentum and angular momentum causing effective weight change and spontaneous acceleration come from? At the magnetic walls Bose-Einstein condensates could be generated and give rise to either super-conductivity or cyclotron Bose-Einstein condensates as generalized spontaneous magnetization or both. This demands that the charged particles at the flux quanta form Bose-Einstein condensates so that they have parallel longitudinal momenta p_L and/or spin and cyclotron quantum numbers n, m. This requires that the spins or momenta of charged particle have same value. Conservation laws require that the increments of quantum numbers in the phase transition go to the roller and would cause weight change in the case of super-conductivity and spontaneous acceleration in the case of cyclotron Bose-Einstein condensate associated with angular momentum.
- 2. How can one understand the correlation between the sign of the weight change and direction of rotation? Could parity breaking - perhaps made possible by large h_{eff} variants of weak gauge bosons - make this possible? What comes in mind is the winding of DNA and twisting of magnetic flux tubes in Sun. Are the flux tubes leaving from rollers transferred to space-time sheets carrying magnetic walls at fixed positions of wormhole contacts? If so the flux tubes emanating from rotating rollers would twist so that they would become chiral. Could this chirality force the dark photons to propagate with higher probability to another direction of the flux tube and induce the apparent weight change by momentum feed due to the transformation of dark photons to ordinary ones followed by absorpion?

The observation of visible and yellow light could be interpreted as a transformation of dark photons to ordinary photons with energies in visible and UV range.

3. Where comes the rotational energy of the roller during spontaneous acceleration and the energy associated with the dark photons inducing weight change?

The simplest explanation is that the formation of magnetic walls liberates energy and this energy goes to the magnetic system in the way described.

Charged particles could also form kind of dark nuclei at the flux tubes and the dark nuclear energy which is assumed to scale down by 1/n in TGD based model of cold fusion, liberates energy. These dark nuclei could transform to ordinary nuclei when interacting with charged systems and would liberate practically all ordinary nuclear binding energy. Could the observed corrosion of copper foils around the rotor and stator could be due to this transformation?

An further possibility could be remote metabolism in which system sends negative energy signal to a system able to receive it. This mechanism might be central mechanism in quantum biology based on ZEO associated with metabolism, motor actions involving signals to geometric past (explaining Libet's classical finding that neural activity precedes conscious decision), and with memory as communications with geometric past.

What is the proper quantum description for the change of weight and acceleration?

- 1. Could the most elegant option rely on a discrete state function reduction sequence for macroscopic quantum states of the tensor product system formed by rollers and the flux tubes leaving them and the return flux tubes at magnetic walls (possibly fused to form magnetic walls)? The states of this system would be entangled pair with vanishing total angular momentum and momentum and thee quantum numbers would be opposite for every state in the superposition. Could these reductions could be regarded as quantum phase transitions? The quantum numbers increments would go to the dark photon many-particle states and dark photons would be absorbed by the rotor and give rise to apparent weight change or spontaneous acceleration. Rollers could be treated as quantal rigid bodies with cylindrical symmetry in the simplest model.
- 2. Could one treat the entire flux tubes coming from the rollers going to larger space-time sheets containing the magnetic walls via wormhole contacts as particle like quantum system and treat the transitions as phase transition between the states of these systems rather than at single particle level?

There is also evidence that the presence of light source below massive object affects its weight by about .1 per cent. This effect could be explained along the same lines. Zero Energy Ontology and the proposed mechanism remote metabolism at the level of dark matter is however needed and this would force to modify dramatically the views about basic interactions at the level of dark matter.

An increase of weight $\Delta g/g \simeq 2 \times 10^{-4}$ is observed for electrets [E4]: this number has appeared in TGD already earlier [?, K95] and in TGD framework could have interpretatation in terms of dark matter layer with mass $M^D \simeq 2 \times 10^{-4} M_E$ at distance of Moon. Amusingly, this change of weight happens to consistent with the "weight of soul" claimed to be 21 g.

13.2 The construction of the magnetic system and findings

The rotating magnetic system is a modification of the homopolar generator (see http://tinyurl. com/cn94kbk) invented by Faraday. Homopolar generator is a metal disk rotating in magnetic field orthogonal to it. A radial electric field $E = -v \times B$ is generated in equilibrium and implies that current follows in the wire, whose end is attached to the boundary of rotating disk. The current can run through a load and the system provides electric power. One must of course feed power to the system to keep disk in rotation.

The system replaces the rotating disk with rollers, which are cylinders rolling along the surface of stator without slipping so that the rotation is transformed to rolling motion: car is familiar example of this. The slipping is prevented by a magnetic cog wheel obtained by inserting orthogonal linear magnets to the stator and rollers.

The patent application represents the role as electric generator as basic function of the system but the reported effects suggest that it can indeed transform to a generator in the sense that the system begins to accelerate at rotation frequency near 10 Hz and produces power. Also a change of weight is observed. These effects make the system a possible example of new physics effects.

13.2.1 Construction

The rotating part consists of rollers, which are cylinders rotating along the stator ring. The radius of the whole system called converter was about .5 m. Stator and rollers were made of the same magnetic material consisting of rare earth metals. The value of the residual induction was B = .85 Tesla with coercive force $H_c \sim 600$ kA/m and with density of magnetic energy $W \sim 150$ kJ/m³. Magnets were constructed using electric induction. Inserts with radial magnetization were added to both stators and rollers (see Fig. 1 at http://tinyurl.com/hb6bfla) in order to build magnetic cog wheel. Inserts had B = 1.2 Tesla, $H_c \sim 1000$ kA/m, and $W \sim 360$ kJ/m³.

Stator and rollers were wrapped with copper foild of thickness .8 mm having direct contact eith magnets at stator and rollers. Between the surfaces of the stator and roller there was an air gap of thickness $\delta \sim 1$ mm.

The magnetizations of both stator and rollers were along the axis of the cylinder but it remained unclear to me whether they were parallel or antiparallel. Antiparallel magnetization would be favoured by the minimization of magnetic interaction energy $E = -\mu \cdot B$ in dipole magnetic field with return flux in direction opposite to magnetization.

The diameter of the stator 1 and the rotor 2 (see Fig. 2 at http://tinyurl.com/hb6bfla) was selected so that the ratio of the stator diameter D and the roller diameter d was integer multiple of 4: $D/d = 4 \times n$. This is reported to be a condition for spatial quantization and achieve resonant mode between the working elements of the device body. If no slippage occurs in the rotation, the velocity v of the roller rotation at its surface is same as the rotation velocity V of roller along stator surface: v = V implies $\omega d = \Omega D$ giving $\omega/\Omega = D/d$. The condition D/d = mguarantees that single full rotation along stator corresponds to m full rotations for roller and this is very natural condition if one considers em waves possibly associated with the motion. Why one must have $m = 4 \times n$ fullrotations per one full rotation along stator is not quite clear. For n = 1this would mean that a rotation of $\pi/2$ along stator means 2π rotation for roller.

The total weight of the system was about 350 kg.

Ring electrode was attached to the periphery of the device (along the ring just outside the roles) connected to high voltage source with stator as positive pole and the outer boundary of roller ring as negative pole. The voltage had typically a limiting value of 20 kV. The use of the radial electric field was reported to stabilize the mode in which the system produces energy.

13.2.2 Observations

Several strange findings are reported. The system was set in motion by using an electric motor and the rotation frequency was gradually increased by increasing the power feed to the system.

The sign of the weight change depends on the direction of rotation. The following describes the situation for which weight change occurs.

- 1. At rotation frequency of 3.3 Hz the weight of the system started to change with the sign of the change depending on the direction of rotation. Fig. 4 at http://tinyurl.com/hb6bfla shows the relationship between rotation frequency f (rpm as unit) and the weight loss $|\Delta G|$ in per cents.
- 2. At rotation frequency 9.2 Hz and the system started to spontaneously accelerate. At this moment the system was coupled to a fist load of 1 kW. At the same time weight loss slowed down to and increased from 30 per cent to 35 per cent during in the range 9.2 Hz-10 Hz. An unpleasant whistling sound was heard. Fig. 5 at http://tinyurl.com/hb6bfla shows also the time development during the period 9.2 10 Hz
- 3. At f = 10 Hz frequency the total load was P = 7 kW. I am not sure whether it was kept in that value during the next period when the rotating frequency was reduced or whether it was reduced gradually. At these values of f and P a high voltage of 20 kV was applied with positive pole at stator. The rotation frequency dropped to 3.3 Hz without any change in weight change ΔG . After than also weight change went to zero. The load of 7 kW caused the fall down of the system. Did the magnetic cogwheel start to slip or what happened?

The behavior of weight change suggests that there was a feed of both momentum (and energy) to the system in the interval 3.3 Hz-9.2 Hz during which $|\Delta G|$ increased. In the interval 9.2 Hz-10 Hz there was energy feed but no momentum feed. For the load of 7 kW the feed of energy was reduced and the rotation frequency started to reduce but $|\Delta G|$ remained the same. At f = 3.3 Hz the momentum feed began to reduce and weight change reduced gradually to zero.

This suggests that three critical frequencies were present. 3.3 Hz, 9.2 Hz and 10 Hz. Above 3.3 Hz the presence of momentum feed is suggestive. Perhaps by a beam of massless particles with downwards direction to cause weight change. In 9.2 Hz-10 Hz range also the presence of beams of massless particles in both directions parallel to rotors was present causing energy feed but no momentum feed. Above 10 Hz and with load of 7 kW the standing wave energy feed stopped and only the momentum feed remained. It did not go to zero at 3.3 Hz but went to zero smoothly so that the effect was not reversible. This might be due to the presence of load.

Also other effects were observed.

- 1. In dark room a coronal discharge was observed around the convertor in form of blue-pink glow and characteristic smell of ozone. Cloud ionization region covering stator and rotor respectively and a toroidal shape. Visible wave pattern - increased luminescence intensity zones of white and yellow light located along the height of the roller was observed. The sound characterizing corona arc was not audible.
- 2. There was also a visible erosion damage to the copper surfaces of the stator and rollers.
- 3. Also vertical magnetic walls with field strength of .05 Tesla and with layer thickness of 5-8 cm and distance of .5-0.6 m were observed around the unit. If I understood the english translation correctly, the direction of magnetic field co-incided with that for the magnetic field created by rollers so that the flux can be interpreted as a return flux from rollers. The pattern was observed also outside the laboratory.

Magnetic walls begin to appear at rotation frequency 3.3 Hz with the intensity of the magnetic field and temperature drop increasing linearly with the rotation frequency. Maximal temperature drop from 22 °C to 6-8 °C inside the magnetic walls is reported.

13.3 Quantum model

The classical model summarized in Appendix does not work. Dark matter realized as a hierarchy of $h_{eff}/h = n$ phases assignable to magnetic body of the system at quantum criticality is the basic idea. The general explanation for the spontaneous acceleration and weight change is transfer of momentum and energy between the magnetic system and its magnetic body.

13.3.1 Some guidelines

What can one learn from homopolar generator?

The patent talks about a modification of homopolar generator (see http://tinyurl.com/cn94kbk), which is basically a rotating metal disk in magnetic field orthogonal to the disk. The modification is that the rotating metal disk is replaced by magnetic cylinders rolling along the boundary of the stator ring.

- 1. As already Faraday observed, a direct current is generated to the wire attached to the boundary of the disk. This suggests that a radial electric field is generated to the disk and in equilibrium the force to rotating charge vanishes so that one has $F = q(E + v \times B) = 0$: this gives $E = -v \times B$. This effect does *not* follow from Faradays law stating that a system moving linearly in magnetic field observes also electric field $E = v \times B$.
- 2. What is strange that the electric field has source: a constant charge density whose sign depends on the direction of rotation. Charge separation would occur: depending on the direction of rotation some amount of positive or negative charge leaves the system and goes somewhere. Also charge of opposite sign could enter from outside.

What is important to notice is that parity breaking in macroscopic length scale takes place. Standard model predicts large parity breaking effects only in intermediate boson length scales. Could large $h_{eff}/h = n$ phases for which weak bosons have Compton length scaled up by n proposed in the model of cold fusion [L38] be involved. The situation would be same as in biology, where chirality selection having no generally accepted explanation in standard model framework takes place.

3. An analogous charge separation occurs in the Pollack effect [L36] occurring when water bounded by gel phase is irradiated with IR light [L36]. Charge separation occurs and so called exclusion zone of thickness up to 100 micrometers becomes negatively charged: the negatively charged region has strange properties and Pollack calls it exclusion zone. The effective stoichiometry of water changes 0 to $H_{1.5}O$ as one proton per probably hydrogen bonded pair of water molecule goes somewhere. In the case of Pollack effect TGD explanation is that positively charged protons go to magnetic flux tubes as dark protons making possible macroscopic quantum effects crucial for life.

Charge separation is central in biology. Cell is negatively charged and also DNA has negative charge of one unit per nucleotide and the proposal is that dark protons are located along flux tube parallel to DNA and provide a realization of genetic code. The chemical realization would be only a shadow of this realization at the level of dark nuclear physics: dark protons would indeed form analogs of nuclei and dark weak interactions would transform part of dark protons to dark neutrons [L44] (http://tinyurl.com/jgfjlbe).

4. What is interesting is that the so called Tewari generator, which is essentially homopolar generator is claimed to produce also over unity effects and in India there is a large scale trial using Tewari space-energy generators as new power source. I have discussed already earlier a model for Tewari generator [L42] (see http://tinyurl.com/z5zm8aa).

A possible connection with biology

The range 9.2 - 10 Hz for the rotation frequency f_0 corresponds to alpha band in EEG and to the fundamental bio-rhythm. 10 Hz frequency corresponds also to the secondary p-adic time scale assignable to electron.

The condition $f = 4n \times f_0$ for the rotation frequency of roller implied by $D/d = 4 \times n$ found to give rise to a resonance corresponds to harmonics of this frequency. For n = 1 (only 4 rollers) one has frequencies 40, 80, ... Hz. 40 Hz is the thalamocortical resonance frequency believe to be crucial correlate of conscious experience. 80 Hz corresponds to a resonance frequency in REG, the EEG counterpart for retina. Fig 1. at http://tinyurl.com/hb6bfla would suggest D/d = 8 or D/d = 12 so that the roller frequency would be 80 Hz or 120 Hz for $f_0 = 10$ Hz.

Maybe also the frequency 3.3 Hz at which the weight change begins could be also seen as an analog of EEG frequency. EEG indeed has a resonance frequency around 3 Hz.

In TGD inspired model of quantum biology the cyclotron frequencies of various biologically important ion in an endogenous magnetic field field $B_{end} = .2$ Gauss (2/5 of the Earth's magnetic field (possibly identifiable as the value of Earth's magnetic field inside organism or farther away from the surface of Earth) are in EEG range and crucial in explaining the effects of ELF em fields on vertebrate brain [J23] [K48] are crucial. Interestingly, for iron ion the cyclotron frequency is near 10 Hz (as also for phosphate ion which might have fundamental implications in living matter [L45]). Could it be that iron ions Fe^{-2} , which are bosons, end up to the magnetic body of the system and form a Bose-Einstein condensate?

This supports the idea about primitive plasmoid like living system having magnetic body and the analog of EEG realized in terms of dark photons. Magnetic body would used "biological body" as sensory receptor and motor instrument and the generation of rotation might be interpreted as a kind of motor action.

What could quantum criticality correspond to?

Quantum criticality is the prerequisite for generation of dark $h_{eff} = n \times h$ phases possibly satisfying also the condition $h_{eff} = h_{gr}$. Quantum criticality corresponds to some kind of instability. The motivation for the hypothesis is that at quantum criticality long range correlations and fluctuations are present and large h_{eff} would give rise to them. How could quantum criticality be realized in the system considered?

Quantum criticality certainly corresponds to the frequency intervals beginning at values 3.3 Hz and 9.2 Hz and continuing to about 10 Hz. At 3.3 Hz the formation of magnetic walls would begin and magnetic field would increase linearly as the function of frequency also the effective weigh change would start to develop. The interpretation would be that B-E condensates analogous of super-conducting phases start to form at flux tubes drifting to the magnetic walls and the momentum liberated in the process goes to the magnetic flux tubes as dark photons transformed to ordinary photons. Actually one would have sequence of quantum phase transitions feeding momentum at discrete steps to the magnetic body and inducing effective change of weight. At 9.2 Hz also Bose-Einstein condensation in angular momentum degrees would occur and also a feed of angular momentum would start to occur in the same manner and lead to acceleration.

Formation of magnetic walls as a quantum phase transition

How the observed magnetic walls could be formed? Could a generalization of Chladni mechanism explain this as an analog of morphogenesis at the level of dark matter?

- 1. Propagating circularly polarized waves with net spin assignable to pairs of MEs and standing waves assignable pairs of these pairs would have cylindrical nodal surfaces, which in the simplest situation would be stationary. Charged flux tubes would drift to these stationary 2-D magnetic walls.
- 2. At the magnetic walls Bose-Einstein condensates would be generated and give rise to either super-conductivity or cyclotron Bose-Einstein condensates as generalized spontaneous magnetization or both. This requires that the charged particles at flux tubes are organized so that they have parallel longitudinal momenta and/or spin and cyclotron quantum numbers n, m. This require that the spins or momenta of charged particle turn to the same direction. Conservation laws require that the increments of quantum numbers go to the roller and could cause weight change in the case of super-conductivity and spontaneous acceleration in the case of cyclotron Bose-Einstein condensate associated with angular momentum.

- 3. Ordinary matter would in turn condense around magnetic body as assumed in TGD inspired quantum biology so that dark morphogenesis would induced ordinary morphogenesis.
- 4. The mechanism would be universal. Even exo-planetary systems are found to be preceded by the formation of concentric rings, which suggests that Chladni mechanism is at work also here and drives dark matter to the rings after which ordinary matter condensed around dark matter.

13.3.2 Standing waves, magnetic walls and Chladni mechanism

In TGD inspired quantum biology morphogenesis could rely on a generalization of Chladni mechanism (for explanation (see http://tinyurl.com/j9rsyqd) [L60]. Chladni mechanism in its original form was a clever trick to make the nodal curves associated with standing waves visible: in the original situation one has vibrating square shaped oscillating membrane and the added particles end up to the nodal lines of the membrane.

In the generalization of Chladni mechanism charged particles would be driven to stationary nodal surfaces of standing waves where they experience no force. One can consider also a more general mechanism in which the nodal surfaces vary slowly in the time scale of the dynamics of charged particles.

One can generalize further: also the magnetic walls carrying dark charged matter could be associated with the nodal surfaces of TGD counterparts of standing waves where charged particles experience no force orthogonal to the flux tube. What is so remarkable that for $h_{eff} = h_{gr}$ given value of h_{eff} would correspond to a given value of particle mass so that various kinds of charged particles would at flux tubes like books in shelves corresponding to particular topics. Living matter would be extremely organized at the level of magnetic body and ordinary matter would organize around magnetic body.

The charged particles at magnetic walls could be bosonic ions or Cooper pairs of fermionic charged particles and form cyclotron Bose-Einstein condensate with all particles in same cyclotron state and with the same spin. The large distance from rotating system would suggest large quantized angular momenta proportional to the distance which is approximately a multiple of the wavelength $\lambda \sim .5m$.

What is interesting that the distance between magnetic walls is about .5 meters asymptotically whereas the cyclotron wavelength of electron in magnetic field of $B_r = .05$ Tesla is $\lambda = .2$ meters. The field giving rise to $\lambda = .5$ meters is by a factor 2/5 times smaller than B_r . Also the endogenous magnetic field $B_{end} = .2$ Gauss relates by the same factor 2/5 to the nominal value of the Earth's magnetic field $B_E = .5$ Gauss. Could it be that the "endogenous" variant of B_r perhaps the dark magnetic field accompanying $B_r = .05$ Tesla - is also now by a factor 2/5 smaller? Or is the value of the field this in the region where the radiation is generated.

If the angular momentum has $\hbar_{eff} = h_{gr}$ as unit, the angular momentum would be scaled up from ordinary. It is not however clear whether this true. Since dark space-time sheets are nfold coverings it could happen that single sheet has fractional angular momentum unit \hbar/n so that n-sheeted structure would have \hbar as unit of angular momentum. Nodal surfaces can be associated also with propagating waves and they would be in the recent case same as those associated with the standing waves.

Chladni mechanism could transcend to a basic mechanism of morphogenesis.

- 1. Charged magnetic flux quanta and therefore also biomolecules would end up to the nodal surfaces of say electric field since the force on them would vanish at the nodal surfaces. This would give stationary structures. MB could control morphogenesis by using this kind of standing waves forcing the formation of various structures at their nodal surfaces.
- 2. The induced fields associated with the simplest "topological light rays" ("massless extremals", MEs) are of form $sin(\omega(t-z))\epsilon(\rho)$, (c = 1). $\epsilon(\rho)$ is polarization function and ρ is a coordinate varying in the direction of local polarization and can be chosen rather freely. Now it is taken to be the radial cylindrical coordinate. $\epsilon(\rho)$ can have zeros, which makes possible stationary nodal surfaces also in the case of propagating MEs.
- 3. The objection is that TGD does not allow single-sheeted realizations of standing waves needed for instance to realize the standing waves assignable to induction coil and wires of electric

circuits. This objection is not lethal. In many-sheeted space-time one can realize effective sinusoidal standing waves as 2-sheeted structures from two MEs propagating to opposite spatial directions and carrying plane waves with a fixed frequency. These two-sheeted structures would serve as basic building bricks. The test particle having necessarily wormhole contacts to both MEs would experience the force caused by the sum of the induced gauge fields assigned to the two MEs. The force would be same as that caused by a standing wave with separable temporal and spatial dependence not realizable as preferred extremal: that is a product of trigonometric functions - say product of form $sin(\omega t)sin(\omega z)\epsilon(\rho)$.

MEs have also always constant direction of polarization. Circularly polarized effective fields could be generated by pairs of MEs for which one has two linear polarizations in orthogonal directions with a phase lag of $\pi/2$.

- 4. The force would vanish at nodal surfaces, which would thus define naturally the shape of a stationary structure defined by molecules. These surfaces would correspond to the vanishing of sin(kz) factor and to the vanishing of $\epsilon(\rho)$ factor.
- 5. One can take several primitive MEs and allow them to have different directions but common frequency. One would obtain effective standing wave with common factorized temporal and spatial dependences given by the sum of spatial parts of the sinusoidal waves. The nodal surface for this wave would correspond to the nodal surface for the sum of the spatial waves and one would obtain arbitrarily complex nodal surfaces.

The nodal surfaces for these waves would naturally associated with the nodes of a tensor network [L51], where the flux tubes of MB indeed meet. Fractal structure with tensor networks with nodes of tensor networks can be assumed in TGD framework. In the recent situation one would have effective 2-dimensionallity and the nodes would be cylinders.

6. There is a connection with holography in which reference wave and the wave of same frequency reflected from the target interfere. Now all waves can be regarded as standing reference waves coming from different directions and generated by magnetic body and propagating along flux tubes of magnetic body. Bio-structures would be formed to the nodal surfaces of this hologram.

Consider now a more detailed description of the recent situation.

1. Magnetic walls would naturally correspond to the nodes of $\epsilon(\rho)$, which would be strictly periodic function or only asymptotically periodic as Bessel function. These nodal surfaces are possible already for single sheeted situation. Cylindrical symmetry would suggest Bessel functions.

The distances between the magnetic walls are in the range .5 m-0.8 m. This length scale would correspond naturally to the wavelength of approximately periodic radial polarization function $\epsilon(\rho)$. The scale naturally corresponds to the radius of stator or the entire system. The frequency corresponding to $\lambda = .5$ meters would correspond to frequency $f = 6 \times 10^8$ Hz. The cyclotron frequency of electron would be 1.5×10^8 Hz in the field of .05 Tesla. Correct value would be obtained for B = .3 Tesla: this would correspond to the value of the magnetic field at the flux tubes of the magnetic body emanating from rollers.

The hypothesis that the cyclotron energies of dark particles are in the range of bio-photon energies - visible and UV- suggests that the value of $n = h_{eff}/h = h_{gr}/h$ satisfies $n \ge 4 \times 10^3$ for the corresponding dark photons in the case of electrons. Note that the gravitational Compton scales $\Lambda_{gr} = h_{gr}/m$ would not depend on the mass *m* of the particles. This realizes Equivalence Principle.

2. If the absorbed photons have well-defined helicity and thus spin, they have circularly polarized waves as classical correlates. MEs do not however allow a polarization changing with time. This problem is circumvented by using union of MEs, which have orthogonal linear polarizations but are in different phase so so that the direction of polarization observed by test particle rotates.

The transfer of spin is expected to be small below 9.2 Hz whereas the momentum is transferred. Hence these pairs could describe propagating waves present below 9.2 Hz. The continual absorption of these ME-doublets would serve as a correlate for the absorption of dark photons and would be a correlate for the weight change

There would be parity breaking in the sense that the rates for the generation of MEs with opposite momentum directions are not same: this would gives rise to a net momentum gain and weight change. Mechanism would be similar to that in the case of radiation pressure. The extreme situation is that there is strict correlation between the directions of rotation and momentum for MEs and dark photons.

3. Standing waves with both polarizations are obtained by combining two pairs of MEs with net circular polarization and having opposite momentum directions to get a 4-plet of MEs representing standing waves with giving spin. These MEs could emerge above 9.2 Hz besides propagating MEs. The absorption of ME-4-plets would be a correlate for the energy and angular momentum transfer but no momentum transfer.

13.3.3 Spontaneous acceleration and weight change

Recall that the general features of the spontaneous acceleration and weight change are following.

- 1. The change of weight increases gradually above f = 3.3 Hz. The interpretation would be that there is not momentum from the dark photons absorbed by the rollers. During rapid acceleration beginning at f = 9.2 Hz the weight change stays the same and after than slowly increases from 30 per cent to 35 per cent. The interaction is that the rate for the absorbtion of dark photons is constant during rapid acceleration and slowly increases after than as function of ΔG : as a function of time the rate could be slowly increasing all the time. This suggests that the momentum distribution for dark protons is not invariant under reflections so that a correlation between weight change and direction of rotations emerges.
- 2. At 9.2 Hz an additional contribution to dark radiation for which net momentum gain is small would emerge: now only energy and angular momentum is fed to the system. The dark photons having both momentum directions with the same probability but same spin direction would be involved.
- 3. Similar effect could be involved with the weight change of a rotating super-conductor observed by Podletnov at Tampere [H14] and later in experiments in which Podletnov and Modanese utilized electric discharges for a capacitor [H13, H7]. The other plate of the capacitor was super-conductor and an unknown radiation was identified as the reasons for the motion of test penduli observed. No exponential reduction of the effect occurred. This suggests that only a very small fraction of the radiation was absorbed or that the effect was a kind of control effect inducing leakage of small amount of ordinary matter to from the test penduli - perhaps as dark matter. A possible explanation is in terms of dark photons such that only small portion of them is absorbed by the test penduli and receives the momentum of the photons. The dark photons could be accompanied by topological light rays.

The loss of electrons cannot explain weight change and acceleration

The transfer of electrons between roller and its magnetic body is very natural explanation for the charging of the roller. Could the loss of electrons with same spin direction to the magnetic body reduce the magnetization of the roller and lead to a loss of spin angular momentum?

1. If the loss of electrons does not affect total angular momentum of the roller, the loss of spin must be compensated by generation of orbital angular momentum so that roller wold experience a torque. Electrons going to the flux tubes of the magnetic body have also momentum. Could the roller receive a recoil momentum from electrons? Could electrons to the magnetic body or from the magnetic body give their spin and angular momentum to the roller.

The number density of negatively charged particles given by

$$n = -\nabla \cdot \frac{E}{e} = -\frac{\omega B}{e}$$

in the units used (c = 1) is extremely low: a fraction of order 10^{-23} of the number density of atoms: roughly 1 electron per mole. The maximal possible spin transfer rate predicted to be $\frac{d\omega}{dt} \frac{B}{e} \hbar/2$ by the above formula should be the torque $Id\omega/dt$ required by the spontaneous acceleration. Here $I = n \times MR^2/2$ is the moment of inertia and $R \sim .05$ m a rough estimate for the radius of the roller. This gives $\hbar B/2ce = \rho R^2/2$. The discrepancy is 25 orders of magnitude for B about 1 Tesla.

Momentum and angular momentum transfer by dark photons

A more plausible explanation is in terms of a momentum and/or angular momentum transfer from the magnetic walls or flux tubes condensing around them.

- 1. The magnetic field of the roller has the same direction as the return flux of rollers so that the natural interpretation is that the phase transition increasing Planck constant fuses the return flux tubes to magnetic walls carrying the dark matter. They could also fuse to single flux sheet. Quantum coherence scale would increase from flux tube radius to the circumference flux tube and the flux wall radius could be proportional to $n = h_{eff}/h$.
- 2. Bose-Einstein condensates of charged particles wih $h_{eff} = n \times h = h_{gr}$ would be formed at the topologically condensed flux tubes at walls or at the wall possible form by fusion of the flux tubes. The dark photons would be liberated in the phase transition turning either momentum or angular momentum or both so that the have same values. If the phase transition liberates energy, the energy liberated would form a many-photon state of dark photons at the flux tubes associated with rollers and stators and the photons would be transform to ordinary photons and absorbed generating effective weight change and spontaneous acceleration.
- 3. The direction of the net dark photon momentum would correlate with the direction of rotation meaning parity breaking present also in the unipolar generator for which the direction of electric field and sign of the induced charge density depends on the direction of rotation. A more general assumption is that the difference between the photons with opposite momentum difference is non-vanishing and correlates with the direction of rotation.

What is the source of energy?

Where comes the rotational energy of the roller during spontaneous acceleration and the energy associated with the dark photons inducing weight change?

- 1. The formation of magnetic walls could liberate energy and this energy could end up to the rotating magnetic system in the manner already described.
- 2. Charged particles could form kind of dark nuclei at the flux tubes and the dark nuclear energy assumed to scale down by 1/n in TGD based model of cold fusion, would liberates energy. These dark nuclei could transform to ordinary nuclei when interacting with charged systems and would liberate practically all nuclear energy. There are indications for the occurrence of this both in cold fusion and in the interaction of so called Brown's gas (see http://tinyurl.com/5tyl92) with metals [H8]. The corrosion of the copper folios around the stator and rotor could be interpreted in terms of transformation of dark nuclei to ordinary nuclei liberating nuclear binding energy.
- 3. A further possibility could be remote metabolism in which system sends negative energy signal to a system able to receive it. Quantum credit card mechanism serving as a general mechanism in remote metabolic energy transfer, motor actions as processes involving signals into geometric past (Libet's findings), and mechanism of memory as communications with geometric past, is a natural proposal in Zero Energy Ontology (ZEO).

The dark matter at flux tubes could gain positive energy by emitting negative energy dark photons, which would be transformed to ordinary ones and be absorbed by the matter at magnetic flux tubes which indeed are cooled. This process could occur in time scale which is fraction of second or even time scale corresponding to the cyclotron time of dark photons. This process should generation of a pair of cyclotron photons at the flux tube of roller and at the flux wall. It is not necessary that the photons have same energy and momentum since the negative energy photon.

Here one cannot avoid few words about TGD inspired theory of consciousness. Large state function reduction meaning the "death" of conscious entity assignable to CD would occur at opposite boundary of CD and the resulting state would be time reversal of the original so that second law would hold in non-standard direction of geometric time and lead to effects apparently inconsistent with second law. The reported cooling of the magnetic flux walls suggests that also this mechanism could be involved. Also the idea about magnetic systems with charge separation as primitive life forms suggests this.

4. One cannot completely exclude even more radical mechanism allowed by ZEO and not breaking conservation laws since the conservation laws hold true only in given scale characterizing CD. The reason is that the states have vanishing total values of conserved charges. The usual conserved charges can be assigned with either boundary of CD and are of opposite sign at the opposite boundaries. In the first state function reduction to the opposite boundary the average values of charges of states analogous to square roots of thermal partition functions can change. This could lead to the increase of the average energy associated with given CD which also increases in size. One could imagine even the possibility that CD increases so that it gives rise to sub-cosmology.

One could imagine that the changes of the arrow of geometric time taking place in the "death" of self with standard arrow of tiem has interpretation as signal sent to geometric past and increasing the energy at "dead" end as also the magnitude of the negative energy at the opposite end of CD. In this manner the energy of CD would gradually increase.

13.3.4 How the system could be scaled?

The system has rather large weight and it would be desirable to study smaller system. Therefore it is of considerable interest to see how the system might behave in the scaling.

- 1. If the quantum critical frequencies 10 Hz an 3.3 Hz correspond to resonance frequencies of EEG and biorhythms, one can hope that they are independent of the scaling of the system.
- 2. The frequency corresponding to the distance between the magnetic walls could be interpreted as cyclotron frequency for the magnetic flux tubes assignable to the electrons at magnetic field of .3 Tesla. This field value could be assigned with the rotor. Scaling of this frequency would scale the distance between magnetic walls.
- 3. The values of the dimensionless parameters, in particular the ratio of the radius of the roller to that of stator should be kept unaffected.

If this view is correct, there should be no obvious problem in scaling down of the system.

13.4 Other examples about weight loss

There are also other experiments involving poorly understood weight change. In the following two examples are considered.

13.4.1 Could photons affect gravitational force?

I participated an intense Facebook discussion on rotating magnetic systems and some-one gave a link to a very interesting experiment in which light arrives horizontally in a box and is reflected there in forth and back in a 6-layered structure [E3] (see http://tinyurl.com/zs9wley). It is reported that the presence of light-box reduces the gravitational force on an object above the box and increases it for an object below the light-box.

Could TGD explanation be similar to that as for the reduction of weight of rotating system in Godin&Roschin experiment [H17]? This might be the case although the reduction of weight is fraction of order .1 per cent and much smaller than the maximal reduction of 35 per cent in
G&R experiment. This could be understood if dark photons with energies scale up by a factor $h_{eff}/h = n = h_{gr}/h$ result as a small leakage from ordinary photons or vice versa. In G&R experiments the beam of photons arriving the system is dark.

After brainstorming the first serious trial to explain the effect led to a strange conclusion: the momentum direction for the dark photons exchanged between the light-box and test mass must be opposite to the momentum. This violates **Quantum Classical Correspondence** (QCC), which is basic principle of TGD. In the light-hearted brainstorming mood I was ready to accept this but soon realized that this won't go. After that it was easy to see that Zero Energy Ontology (ZEO) solves this problem. This however leads to a dramatically new manner to interpret gravitation and also other interactions. This interpretation is however not in conflict with existing physics although it would conform with the vision of Sheldrake.

Consider first how gravitational force by dark gravitons giving rise to momentum exchange along the flux tubes connecting the test mass to Earth could work.

- 1. The weight gets momentum increments Δp assignable to gravitons with some rate and this gives rise to net momentum transfer rate dp/dt defining gravitational force. Reaction law holds in the sense that mass gets a momentum increment Δp when a momentum $-\Delta p$ travels along flux tube to Earth getting opposite momentum increment. Note that the direction of Δp is **opposite** to the direction of travel of graviton in positive energy ontology! Also the energy of the graviton is negative.
- 2. This does not conform with the classical expectation about (virtual) gravitons as a localized wave packets. Momentum increment $-\Delta p$ can be said to travel in direction of Δp rather that in its own direction as one might expect!

How could one cure this problem?

- 1. Should one give up QCC although it is basic principle of TGD? Could one argue that gravitation is quantum macroscopic interaction - something totally different from say entropic gravity - and one must speak of non-localized waves of momentum Δp in the scale of the entire system even in astrophysical situations so that classical intuition could fail. This is what TGD indeed predicts via $h_{eff}/h = n = h_{qr}/h$ hypothesis.
- 2. Or should one replace positive energy ontology with ZEO and interpret the momentum exchange as taking place in reverse time direction. ZEO could allow to achieve this correspondence in terms of remote metabolism in which test mass sends negative energy dark gravitons travelling in reversed direction of geometric time to a system able to absorb them and gains positive energy as a recoil.

Test mass would send to the geometric negative energy dark gravitons with momentum - Δp (this momentum is directed upwards to the light box getting positive energy gain and downwards direct Δp p as a recoil. The QCC would not be lost because of time reversal. Since the virtual graviton propagates backwards in time, QCC is true: situation is PT reversal of a positive energy dark graviton with momentum Δp propagating in its own direction.

3. Are planets then primitive conscious entities soaking up gravitational energy from Sun?! Or does this happen in dark sectors whereas at classical level gravitation would be described much as in GRT. From this there is not a long way to the idea that living organisms on Earth soak up energy from Sun also a dark photons. All physical systems would be trying to steal energy from each other! One can safely give up the belief that Nature is somehow innocent. This sounds a pre-Keplerian idea but in ZEO it need not be inconsistent with basic laws of physics. This picture conforms with the views of Sheldrake about learning and morphogenesis.

Consider now the experiment in this picture. What would happen as one adds light-box below the test mass?

1. This picture about gravitational force as remote metabolism generalizes to the recent case by replacing negative energy dark gravitons with negative energy dark photons. Test mass would be a primitive living system and would gradually learn to utilize light-box as an energy source using remote metabolism. This would conform with the observation that it takes time for the effect to emerge.

- 2. Test mass would send negative energy dark photons along gravitational flux tubes and some fraction of them would be absorbed by the light-box as they transform to negative energy bio-photons with some rate at least if quantum criticality in some sense is realized: in what sense remains an open question. Does quantum criticality develop during the time needed for the effect to emerge. Certainly the fact that the photons in the light-box have energies in the range covered by bio-photon energies matters.
- 3. If negative energy dark photons have Δp parallel to the direction of motion with reversed arrow of time, Δp is directed downwards and the effective weight increases if the box is below the test mass. If the box is above the test mass the effective weight is reduced. This is what has been reported in the article. From the size of the reduction of mass about 1 per cent one in principle could get idea about the rate for the transformation of dark photons to ordinary visible photons.
- 4. A related TGD inspired suggestion is that topological light rays (MEs) parallel to the magnetic flux tubes mediating the gravitational interaction are generated and dark photons can be assigned to them. The fundamental property of MEs is that pulses can propagate only in single direction and this could relate closely to the sign of the force. Dark photon Bose-Einstein condensate propagating in single direction is generated as photons from the light-box transform to dark bosons. For given ME all dark photons must be collinear just like the classical pulses inside ME propagate only in single direction. The direction would be towards the test mass and opposite to the direction of momentum exchange involved to make the interaction attractive. Also now the TGD analogs of standing waves might be involved and would correspond to pairs of "plane wave" MEs such that the sums of their em fields are standing waves.
- 5. What is interesting that this model could also explain the well-known fluctuations in the value of gravitational constant measurements (see http://tinyurl.com/kvczx7g and http://tinyurl.com/jnb8mv91). Also Sheldrake notices the reports about the variation of G (see http://tinyurl.com/zq7ee57). The largest variation is about one percent from the average value, and there is evidence that the measured value varies periodically with a period of one sidereal day (galaxy as rest system).

This suggests that the test mass soaks energy from the flux tubes of galactic magnetic field: I have indeed proposed that they mediate the gravitational interaction of Earth (the local geometric entanglement of galactic flux tubes could be essential for the formation of various biological or even more general material structures). The effectiveness of soaking could depend on the angle characterizing the orientation of the gravitational flux tubes with respect to the line connecting Earth to Galactic center varying in the range $[0, \pi]$. The effectiveness could also depend on the position of Earth at its orbit around Sun giving annual variation: could the local density of the galactic flux tubes have periodic variation? There are also other interesting appearances of sidereal day and year in living matter [L49].

The long measurement times should tend to affect the measured value of the gravitational constant G. One should arrange the instruments so that the are not below or above the test mass.

One can criticize the idea.

1. Skeptic of course argues that the assumption about all matter having some aspects assigned to living systems is worst kind of pseudo-science that they have ever met and that now these quantum crackpots try to bring physics back to pre-Keplerian times. ZEO is however completely consistent with basic laws of classical physics and quantum physics. The fact is that TGD predicts that dark matter as a key aspect of what it is to be living. Adelization of physics means that cognition is present in all scales - already in elementary particle length scales as the success of p-adic mass calculations suggests. TGD also predicts hierarchy of conscious entities. Also skeptics explain all our activities in terms of conscious choices. Maybe

also skeptics should finally accept free will as a fact and try to explain it scientifically. The consolating news for skeptics is that in ZEO one can indeed assign to consciousness causal powers without ending up with conflict with the laws of physics.

2. Physicalist would argue that one can just assume that light-box has additional **attractive** interaction with test mass analogous to gravitational interaction. This interaction should be electromagnetic, certainly not the extremely weak gravitational interaction. Coulomb attraction is probably not in question. The interaction energy for this interaction should increase as the distance between test mass and light-box decreases to give attractive force as gradient of interaction energy - just as in the case of gravitation. If this picture is correct, one should be able to express this interaction in more familiar terms.

13.4.2 Weight change for electrets and "weight of soul"

Also the weight of electrets have been found to change as the Research Gate conference article or Schreiber and Tajmar reports [E4] (see http://tinyurl.com/hh88frv). They refer also to other works reporting anomalous looking weight changes. Recall that electrets are systems possessing spontaneous electric polarization and therefore analogous to magnets. Electret property allows to transform electric signals to mechanical and vice versa. Living systems are full of electrets.

Electrets were produced from organic materials (organic origin might be relevant) by a procedure described in the article beginning with melting at temperature 120 °C to a molten state followed by an application of an external high voltage (10 kV) electrostatic field forcing the microscopic electric dipoles to orient in parallel leading to complete solidification until room temperature was reached.

Fig. 3 describes the schematic model for the resulting electret containing parallel electric dipoles and free positive and negative charges. The polarization of the electret its not completely stable and can change or disappear. There are two kinds of free charges near the ends of the electret: the region near negative pole contains more positive than negative charges and the region near positive pole more negative than positive charges. There are two kinds of charges known as heterocharges and homocharges and these charges have different relaxation times. Therefore the relaxation can lead to change of the polarization voltage and even of its direction.

Two kinds of measurement were performed. Both the resulting polarization of electret and its weight were measured in the first experiment (see Fig. 7 of http://tinyurl.com/hh88frv). The voltage for these electrets changed after half an hour: the voltage dropped first from 3 kV to about 2.82 kV and then suddenly jumped to 3.425 kV. The weight showed after an initial fluctuation period a sharp increase to a saturation value taking place after 5.5 hour so that there was 5 hour lag. For an unpolarized electret the weight was found to increase steadily (see Figure 9 of http://tinyurl.com/hh88frv). The overall change of the weight during 20 hours was $\Delta g/g \sim 2 \times 10^{-4}$ in both measurements.

The change of the electric field of the polarized electret was accompanied by an increase of weight followed by a fluctuating period with vanishing average weight increase followed by a sudden increase after 5 hours followed by steady increase. The overall change in both cases was about $\Delta g/g \sim 2 \times 10^{-4}$. Maybe the behavior of polarized electret could be seen as that of a depolarized electret perturbed by the change in the value of polarization. There was 5 hour lag before the sudden change in $\Delta g/g$: as if the steady weight increase occurring for electret with no polarization had been prevented by the change of the polarization and transformed to a fluctuation lasting for about 5 hours before returning to nearly normal value.

The challenge is to understand the cause of weight increase and why it was affected by the change in polarization. The models for the weight change of a rotating magnetic system and for the weight change induced by the presence of light-box suggests that the continual feed of dark photons transformed to ordinary photons was involved. One can consider two options in this framework: the electret sends negative energy dark photons to some system below the electret able to receive them or the source system located above the electret sends positive energy dark photons to the electret.

1. Since the electret system consists of organic material one might think that it could still be able to regenerate a connection to its magnetic body carrying magnetic field - say the endogenous magnetic field $B_{end} = .2$ Gauss. Perhaps the transformation to electret returned the ability to regenerate this connection by generating an ordered phase of dipoles: could one say that the external field "revived" the organic material.

2. The magnetic body located above the system send dark positive energy photons to the electret in which they are partially transformed to ordinary photons. B_{end} can have flux tubes also below the Earth's surface and the electret could get energy by remote metabolism by sending negative energy dark photons downwards constantly. This would give rise to a increase of the effective weight.

What other models can one imagine?

- 1. One can also imagine that dark mass of order $\Delta m/m \sim 2 \times 10^{-4}$ flows from magnetic body to the system and transforms to ordinary matter.
- 2. I have already earlier encountered the number 2×10^{-4} assigned with endogenous magnetic field $B_E = .2$ Gauss [?, K95]. The proposed interpretation was that the flux tubes of B_{end} correspond to gravitational flux tubes for dark mass $M_D \sim 2 \times 10^{-4} M_E$. Could one think that the revived system regenerates gravitational flux tube connections to this mass and experiences the gravitational field generated by it?

The arguments used however strongly suggest that M_D must reside at the distance of Moon at a spherical layer: this conforms with the vision about how the condensation of visible matter around dark matter creates the astrophysical objects. In Newton's theory however the net gravitational force should be very small at the surface of Earth since different contributions to the force would interfere. M_D should reside considerably below the surface of Earth for this model to make sense.

Flux tube picture distinguish between TGD and Newton's theory could however save the situation: the gravitational flux would arrive along flux tubes through wormhole contacts below the surface of Earth and then spread out radially and give an additional contribution to the Earth's gravitational field and cause the weight increase. This explanation does not apply to rotating magnetic systems nor to the change of weight due to light.

The objection is that the system cannot just decouple from the flux tubes. Also the conservation of gravitational flux which could correspond basically to the conservation of Kähler magnetic monopole flux prevents this.

The most attractive solution of the problem emerged from the observation that the "inner inner" core of Earth having radius about 300 km has mass of order $M_D = 10^{-4}M_E$ if the density in this region is the average density of Earth. Probably M_D is somewhat larger meaning that actual estimate is higher, and even $M_D = 2 \times 10^{-4}M_E$ giving 4 times higher cyclotron energy scale - bio-photon energies include visible and UV range so that this might well make sense.

3. The third option is that the mass of electret has also dark contribution coming perhaps from its own personal MB - its "soul"! MB as intentional agent indeed behaves in many respects like "soul". This is just what I have proposed many years ago: as the ageing biological body gets uninteresting, MB finds more interesting target of attention. In this case death would mean the loss of MB and also loss of weight $\Delta m/m \simeq 2 \times 10^{-4}$ if the ratio M_D/M is universal.

Also Earth could have MB and it could indeed correspond to the dark mass at distance of Moon. Could the flux tubes from Earth carrying monopole flux go at this distance to another space-time sheet through wormhole contacts carrying quantum numbers of dark matter particles at their throats and return near Earth's core, where they would return to the original space-time sheet and turn back to form a loop? Could these loops be just elementary particles with $h_{eff} = h_{gr}$?

An interesting test is to see what happens as organism dies: is it weight changed - reduced - as these experiments would suggest? For a weight of 100 kg the weight reduction would be 20 g if one can extrapolate from the above measurements. Amusingly, the "weight of soul" has been measured

and - believe or not - the average result happens to be 21 g (see http://tinyurl.com/k7d8vuy! Of course, one can invent many explanations for the weight change and also challenge its occurrence, and skeptics of course ridiculize the idea about detecting the possible weight change because someone has uttered the word "soul" in this context.

13.5 About the description of rotating magnetic systems in zero energy ontology (ZEO)

I have worked for decades in an attempt to understand the findings of Godin and Roschin [H18, H17] about strange effects in rotating magnetic system [K15]. The possible connections with TGD inspired quantum biology are discussed in [L59]. The developments in zero energy ontology (ZEO) and increased understanding of magnetic fields in TGD framework allow to lookat the situation again. I am not an engineer but more precise model might allow development of simpler systems catching just the essentials and also scaling down of the system of Godin and Roschin perhaps allowing easier testing of the model.

13.5.1 Summary of the updated picture

Basic new ideas

The basic new ideas brought by TGD are present already in the earlier model [K15] but in less developed form.

- 1. Dark matter is assigned with the hierarchy of effective Planck constants $h_{eff} = nh_0$, $h = 6h_0$ [?, K95]. The strengthening of hypothesis introduces gravitational Planck constant $\hbar_{eff} = \hbar_{gr} = GMm/v_0$ introduced originally by Nottale [E1] and assigned with flux tubes mediating gravitational interactions. h_{gr} can have so large values that $E = h_{gr}f$ for cyclotron frequencies in ELF range (say 10 Hz) are in the range of bio-photon energies in visible and UV energies. One can assign the analog of gravitational Planck constant also to flux tubes mediating electromagnetic and other interactions: for instance $h_{eff} = h_{eff} = nh_0$ would be natural in the case of of the observed flux walls.
- 2. Dark matter can perform macroscopic quantum jumps since various quantum scales scale up like h_{eff} (Compton lengths) or even h_{eff}^2 (atomic orbitals).
- 3. Magnetic body (MB) is key notion. It has as building bricks magnetic flux quanta. Typically flux tubes and flux sheeets. It consists of two kinds of flux quanta. Flux can be vanishing, which corresponds to Maxwellian case. The flux can be also non-vanishing and quantized and corresponds to monopole flux. In this case magnetic field requires no current to create it. This option is not possible in Maxwellian world. These flux tubes play a key role in TGD Universe in all scales.

Also Earth's magnetic field with nominal value $B_E = .5$ Gauss has these two parts. Monopole part corresponds to $B_{end} = .2$ Gauss explaining strange effects of ELF em radiation to the physiology and behavior of vertebrates. The presence of this part identifiable as monopole flux explains why Earth has magnetic field: this field should have decayed long time ago in Maxwellian world since it requires currents to generate it and they disappear. Magnetic fields of permanent magnets could have a monopole part consisting of flux quanta. Electromagnets do not have it. For flux walls the magnetic field is of order B = .05 Tesla and much stronger than B_{end} , whose cyclotron frequencies are involved also with the rotating magnetic system so that different magnetic fields are in question.

MB would carry dark matter as $h_{eff} = n \times h_0$ phases and act as a "boss" controlling ordinary matter [L107]. Communication to and control of biological body (ordinary matter) would be based on dark photons, which can transform to ordinary photons and vice versa. Molecular transitions would be one form of control.

4. ZEO predicts that the arrow of time changes in "big" state function reductions (BSFRs - ordinary state function reductions as opposed to the counterparts of weak measurements or

"small" SFRs). This would happen at magnetic has dramatic implications. Time reverse dissipation looks like energy feed from the environment to system. Self-organization involves always energy feed and generation of structures rather than their disappearance in apparent conflict with second law. Self-organization would correspond to dissipation in reversed time direction implied by generalized second law. No specific mechanisms would be required and only metabolic energy storages- systems able to receive the energy dissipated in reversed time direction - are enough. Obviously this provides a totally new vision about energy technology.

Basic picture about rotating magnetic systems

What is observed in rotating magnetic systems is following.

1. As the rotation velocity for the roller system around stator magnet approaches to 10 Hz frequency, which is basic biorhythm, the system starts to accelerate spontaneously around 9 Hz: the critical frequency is quite not the same for opposite rotation velocities. The rotating system must extract energy and angular momentum from some source. A good candidate for the apparent source of energy is the MB of the system. There should be an exchange of energy and angular momentum to system (call it "biological body" BB in the sequel) and MB.

Depending on the rotation direction the weight of the rotating system increases or decreases. The interpretation is as additional force due to the exchange of momentum between MB and BB. The exchanged momentum would have direction depending on the rotation direction.

2. Cylindrical magnetic walls with magnetic field strength about B = .05 Tesla are observed and the temperature at their position is lowered. This behavior is in conflict with standard thermodynamics but would conform with time reversed thermodynamics. This would conform with time reversed dissipation from a system identifiable as MB of the rotating system. This mechanism would be completely general mechanism of metabolism in TGD being present in all self-organizing system. This would look like cooling of the air for the observer with standard time direction. One could interpret the situation as extraction of thermal energy from environment by walls of MB and its transfer to the BB leading to cooling. Also angular momentum and momentum would be transferred.

In ZEO this would conform with the occurrence of macroscopic BSFR - a phase transition changing the arrow of time at MB. The phase transition taking place instantaneously with respect to *subjective time* identifiable as sequence of SSFRs must be distinguished from what happens after it with reversed arrow of *geometric time*. The quantum jump would be instantaneous and completely analogous to what has been observed by Minev *et al* in atomic systems.

- 3. The air in around rotating magnetic system emits visible maybe also UV light which can be assigned with molecular and atomic transitions. This suggests that transformation of dark cyclotron photons in B_{end} with ELF frequencies and very large $h_{eff} = h_{gr}$ to photons identified in bio-systems as time reversed bio-photons inducing transitions of molecules to higher energy states takes place. Observer would see emission of ordinary photons generated as molecules return to the ground state. Also direct transformation to bio-photons could take place and produce diffuse background. The cyclotron photons would have energies, which do not depend on the mass of charged particle since cyclotron energies are proportional to \hbar_{gr}/m and one has $\hbar_{gr} \propto m$. For 10 Hz frequency would in the range bio-photon energies (visible and UV).
- 4. The rotation of rollers occurs without slippage with velocity v. The rotation frequency around the central cylinder is $\Omega = 2\pi F = v/R$. The spin velocity of the rollers with of radius r around their axis $\omega = v/r$ and by a factor R/r higher than Ω . During acceleration Ω is in the range 9-10 Hz. This frequency defines fundamental biorhythm - alpha rhythm- so that the analogy with TGD inspired quantum biology suggests itself strongly. 10 Hz frequency could be critical rotation frequency for the rollers around central cylinder.

The energy transfer between MB and BB could take place resonantly at this frequency. Other important resonance frequencies could correspond to those assignable to EEG. The cyclotron

frequencies of those biologically important ions that can occur as mechanical resonance frequencies in the system are especially interesting and would represent coupling between MB and BB. In particular, proton has cyclotron frequency 300 Hz in B_{end} . The spinning frequencies of the rollers bring in additional frequencies above 10 Hz determined by their rotating velocities with respect to the central cylinder.

The analogy with biology forces to ask whether the phase transitions generation of flux walls is central also in quantum biology: consider flux walls possibly assignable to axonal membranes.

5. The biologically important cyclotron frequencies in magnetic field $B_{end} = .2$ Gauss should correspond to rotation frequencies of the rotating magnetic system. The scaling down of the system should not be problematic. $\Omega = v/R$ means that keeping Ω constant and reducing R, reduces also v in same proportion. Note that centripetal acceleration v^2/R produces problems for too large value of R. Rotation frequencies should not change in the scaling. Since one has $\omega = v/R$ this allows reduction of the size of the system if rotation velocities are scaled in the same matter. The scaling of magnetic and electric fields need not be so simple thing.

13.5.2 Updated model for rotating magnetic systems

The observed anomalies suggest change for the arrow of time and this makes the interpretation as macroscopic BSFR at MB of the system plausible interpretation. The value of h_{eff} should increase to generate the observed effects analogous to self-organization in long scales. Quantum coherence length would increase.

What could happen at MB before the transition

What could happen at MB in the phase transitions? Consider first the MBs before the transition.

- 1. Before phase transition monopole flux tubes form MB carrying dark matter. Monopole flux tubes would be in question and this requires permanent magnet for which the monopole part of magnetic field would not require currents as sources. The magnets created by electromagnetic currents do not satisfy this condition.
- 2. One can of course ask whether the magnetic flux tubes of the stator magnet are really at rest. Could the interaction with the flux tubes of the rotating rollers force also them to rotate so that the two magnetic fields would form single coherent rotating structure?
- 3. Before the transition the flux tubes of the MBs of the rollers would rotate as a whole around the central cylinder. The flux tubes would also rotate around the axis of the roller with the rotation velocity of the rollers. Also the dark matter at the flux tubes of rollers would rotate.

What could happen at MB in transition

What would happen in the transition.

- 1. What suggests itself is that the magnetic flux tubes of the stator magnet increase in thickness and fuse to the observed magnetic walls having thickness about 5 cm and distance about .5 meters. The field strength is of order .05 Tesla. The cylinders would be closed surfaces carrying monopole flux so that torus-like configurations obtained by taking flux tube which is closed solid torus highly stretched in vertical direction rotating it around vertical axis outside it and near to the second side. This gives torus topology with flux flowing through the section with constant height. Various walls would correspond to this kind of structures inside other looking like cylinders.
- 2. What would happen to the flux tubes of the rotating rollers? Could also these fuse to form magnetic walls in shorter scale? What about these structures: could also these fused to larger cylindrical structures accompanying magnetic walls. There are no reports about their possible occurrence.

3. Does it make sense to speak about rotating flux walls? In Maxwellian electrodynamics this is not possible without breaking of the rotational symmetry. In TGD framework this is possible since Kähler gauge potential would be different for rotating Kähler magnetic field and correspond to different space-time surface having different induced metric. Rotating Faraday disk develops a voltage between its boundary and center giving rise to electric field $E = v \times B$. This observation is problematic from the point of view of Maxwellian theory since strong parity breaking is involved.

On the other hand, this observation suggest that the assumption about rotation of the magnetic flux tubes of the stator magnet would not mean too strong deviation from Maxwellian view in TGD. h_{eff} hierarchy in TGD allows strong parity breaking effects, which are indeed present in living matter. Also the earlier model of the system involves parity breaking assigned with the dependence of the effect on the direction of rotation.

As a matter of fact, the exact cylindrical symmetry is broken by the magnetic cogwheel structure of rollers (12-fold cyclic symmetry) and stator magnetic ($12 \times 12 = 144$ -fold cyclic symmetry) preventing the slipping of the rollers.

The following remarks about magnetic fields and corresponding cyclotron frequencies suggest that dark electrons play an important role.

- 1. The magnetic field strength for stator and rotor magnets was $B_M \sim 1$ Tesla. For electron this corresponds to cyclotron wavelength $\lambda = c/f = 1$ cm. The thickness of the magnetic walls was 5-6 cm. If the monopole flux part of the magnetic field is roughly r = 2/5 of the measured field as in the case of B_E , the cyclotron wavelength increases by a factor 5/2 to 2.5 cm, which is roughly one half of the thickness of magnetic walls. There could be thus be a connection.
- 2. The magnetic field $B \sim .05$ Tesla of magnetic walls corresponds to electron's cyclotron wavelength $\lambda_c = .2$ meters. The distance between magnetic walls was d = .5 .6 meters. If the value of the monopole part of the flux is 2/5 of the entire flux as for B_E , λ_c increases to $\lambda_c = .5$ meters.

Also endogenous magnetic field B_{end} is involved

The appearance of biologically important frequencies suggests that besides the magnetic fields associated with the magnetic walls also the endogenous magnetic field B_{end} plays an important role.

1. Also $B_{end} = .2$ Gauss could play a central role defining the monopole part of Earth's magnetic field could play a role. The transition correspond to frequencies around 10 Hz frequency of rotation around stator magnet and the transition begins around 9 Hz frequency. Around 10 Hz rotation frequency one might expect a resonance coupling of the rotating motion of the rollers to cyclotron transitions in $B_{end} = .2$ Gauss at this frequency. Iron ions have cyclotron frequency around 11 Hz in B_{end} to be distinguished from the magnetic fields of the stator magnet and rollers.

The metal ions possible in the system would have cyclotron frequencies and these should be realizable as rotation frequencies using suitable radii for rollers. Resonance would require correlation between the radii and atomic numbers of the metals involved. A strong analogy with biologically important ions would emerge.

- 2. B_{end} is by factor 4×10^{-4} weaker than the magnetic field $B \sim .05$ Tesla at magnetic walls. The frequencies associated with the system cannot correspond to B. The value of $n = h_{gr}/h_0$ required by the assumption that ELF frequencies correspond to bio-photon energies is very large - the order of magnitude is of order $n \sim 10^{13}$ for 10 Hz frequency. For h_{gr} must be assigned to gravitational flux tubes carrying no monopole flux with single sheet carrying B_{end} .
- 3. One can of course consider the interpretation of the measured magnetic field B in manysheeted space-time. Does the measured B correspond to the sum of identical magnetic fields

 B_{end} over the $n = h_{eff}/h_0$ sheets of many-sheeted space-time? Cyclotron frequencies as purely local quantities would correspond to the field B_{end} at single sheet. If the measured magnetic field is $B_{meas} = n \times B_{end}$, one would obtain the estimate $n \sim 2.5 \times 10^3$. This could be interpreted in terms of the proposed electromagnetic variant $h_{em} = nh_0$ of h_{gr} having much smaller value.

Could the important mechanical frequencies of the system are equal to cyclotron frequencies in B_{end} ?

- 1. F = 10 Hz, which corresponds roughly to the cyclotron frequency f_c of Fe⁺⁺ ion in B_{end} .
- 2. Proton's cyclotron frequency in endogenous magnetic field $B_{end} = .2$ Gauss is $f_c = 300$ Hz. Can one get this frequency as a mechanical frequency? There were $N_r = 23$ rollers.
 - (a) The ratio r/R was integer $N \ge 12$. The frequency associated with the rotation of roller is $f_r = v/r = NF \ge 12F = 120$ Hz. N = 30 (r = 5/3 cm) would give $f_r = 300$ Hz but N = 30 looks too large.
 - (b) The periodicity of the roller configuration implies frequency $f = N_r F = 23F = 230$ Hz for F = 10 Hz but allowing no identification of f as cyclotron frequency.
 - (c) The realization of magnetic cogwheel involves 12-fold periodicity of the roller giving frequency $12 \times 23F = 2.760$ Hz frequency. At stator one obtains $N \times 12$ fold periodicity of stator surface and $12N \times 10 \ge 1,440$ Hz frequency.

About the energetics of the dark matter after the transition

What happens to the dark matter at flux tubes in the phase transition? Especially interesting is the energetics of the transition. One can use observations about cooling associated with magnetic walls and molecular emission lines near rollers. The dissipation of energy by dark matter at magnetic walls and at MBs of the roller possibly fused together could could explain these observations.

1. A transfer of energy, angular momentum, and momentum must take place between the system formed by rotating rollers and MB carrying dark matter. This would happen in the phase transition/quantum jump. Dark matter at flux quanta must lose angular momentum, energy and momentum to the BB of the roller system. Most naturally the MBs of rollers are in question. This requires that roller flux tubes fuse to flux walls. About whether this occurs there is no direct experimental information.

If also the flux tubes of stator magnet rotate they can fuse to single magnetic wall and if the dark matter comes the transfer of conserved quantities to roller system would take place. The fusion of flux tubes to flux walls would force the acceleration.

2. After the transition occurs dissipation in reversed time direction making itself visible as cooling at magnetic walls assignable to the stator magnet. In standard time direction the rotating system accelerates but in reversed time direction it loses energy and angular momentum and possibly also momentum. This would be induced by time reversal at MB. Does the time reversed dissipation occur via MB of stator magnet or directly?

Does the cooling of environment correspond to

- (a) dissipation of the energy of the MB of stator magnet or
- (b) dissipation of the energy of rotating system via the MB of stator magnet?

For the latter option one could say that the MB of stator magnet extracts thermal energy from environment and provides it to the rotating system. For the first option also rotating system would do this and this does not look plausible since the time scales for time reversals are much shorter for ordinary matter. For second option the time reversed classical time evolution would provide a correlate for the quantum jump in accordances with quantum classical correspondence. 3. The emission lines from molecular transitions should take place after the transition as time reversed emission of dark photons from MB transforming to counterparts of bio-photons absorbed by the molecules of air and looking like molecular emission lines in standard time direction. Since dark photons transform first to ordinary photons standard observer would see emission of ordinary photons at bio-photon energies.

The density of excited molecules would grow as time increases in non-standard direction. For the standard observer this would look reductio of the density of excited states. If the dark photons would have energies in visible and UV range, ionization would be gradually reduced in standard time direction and seen as emissio of photos with bio-photon energies.

Since roller MBs are nearest to rollers, the MBs of the rollers would naturally provide energy, angular momentum, and momentum to the roller system in the transition. This could occur if the flux tubes of rollers fuse to flux walls so that the dark matter at them can come to rest after fusion. Time reversed absorption of dark photons from the rollers could cause the molecular emissions.

The transfer of conserved quantities after the transition

The first question whether there is any classical description for the transition itself or is the only description in terms of what happens after it. If the quantum jump occurs discontinuously, this seems to be the case. Quantum classical correspondence suggests that the classical description based on what happens after the transition is the only possibility. The observer would talk about extraction of energy from environment. Time reversed dissipation would be the description of the system itself.

Suppose that both roller flux tubes and and those of stator magnet fuse to magnetic walls and contain after transition dark ions rotating around the walls and that there is also momentum in longitudinal direction with opposite momentum in the magnetic system causing the observed change of the weight. Suppose also that dark matter rotates and there is compensating angular momentum contributing to the of the roller system.

The natural identification for the transfer of conserved quantities would be in terms of energy, momentum, and spin, and angular momentum of dark photons.

- 1. In the transition energy and angular momentum are transferred to the roller system instantaneously. Energy and rotational angular momentum are dissipated in reversed time direction and for the external observer the roller system seems to accelerate and gain energy.
- 2. Photons have also momentum. The roller system would receive momentum in the quantum jump. The dissipation of this momentum would be seen as a force meaning gradual change of weight by external observer. The simplest option is that the momenta at BB and MB of the system are opposite in the final state after which dissipation starts.

Why the sign of weight change depends on the direction of rotations. This would suggest that large parity breaking effects characterizing also living matter are involved. Dark photons (expected to have ELF frequencies) transfer both momentum and spin and rotational angular momentum.

The states corresponding to different directions of rotation are mirror images from the behavior of magnetic field in reflection. How good approximation reflection symmetry P is?

1. If parity is not violated the behavior $p \to -p$ and $J \to J$ in reflection P implies increase or loss of weight depending on the direction of rotation as indeed observed. Acceleration of rotation would take place in *both cases* as observed. The critical rotation frequency is different so that parity violation takes place. In standard model framework parity violation is large.

In this case the helicity of photons proportional to the inner product $p \cdot s$ and $p \cdot J$ of photon momenta would be different for the two cases. The helicities $p \cdot s$ of dark photons would be different in the two case cases and correlated with the direction of rotation.

2. Note that the generation of $E = v \times B$ for Faraday disk involves also parity violation and could take place also now for the rotating magnets. This electric field has non-vanishing divergence and the divergence giving charge density is opposite for the two rotation directions. This should give rise to the charge density of the system a contribution depending on the direction of rotation.

13.5.3 Is the cooling of the environment enough to explain the acceleration

The classical description of the energy transfer after the transition by standard observed would suggest that the MB of stator magnet extracts energy from the thermal energy of air leading to the lowering of the temperature by about 6 degrees. The MB of roller system fused to a single magnetic wall would extract energy from the transitions of the air molecules visible as emissions of ordinary as dark photons transform to ordinary photons and also from the air near the rollers. The energy from MBs would be transferred to the roller system.

One can make a rough estimate for the contribution of thermal energy to see whether it is significant.

- 1. The mass density of O_2 molecules $\rho = 1.225$ kg m⁻³ giving for the number density of O_2 molecules $n = 3.4 \times 10^{25}$ m⁻³.
- 2. Temperature is T = 290 K and is lowered by about 6 K. Thermal energy of molecule associated with translational motion is $e_T = 3kT/2 \simeq 4.4 \times 10^{-2}$ eV at room temperature.

The density of thermal energy $\rho_T = ne_T = 1.5 \times 10^{23} \text{ eV/m}^3$. Energy of 1 eV corresponds to $eV = 1.6 \times 10^{-19} \text{ J}$ so that one has $\rho_T = 2.4 \times 10^4 \text{ Jm}^{-3}$.

The change of thermal energy is for the reduction of temperature by 6 K equal to 6×10^{-4} eV fraction $\epsilon = 1.8 \times 10^{-2}$ of thermal energy. The energy gain per volume equals to

$$\rho_g = \epsilon \rho_T = 4.2 \times 10^2 \mathrm{Jm}^{-3}$$

3. Assume that magnetic wall associated with the stator magnet has thickness $\Delta R = .05$ meters and radius of $R_{min} = .5$ meters. Walls are reported to appear at radii $R_n \sim nR_{min}$, $n = 1, 2, \dots$ No upper bound for their heights h is given. They could correspond to the return flux for the magnetic system or stator magnet.

For a wall of height h_n (the real height is larger) the volume of the wall with radius R_n is

$$V_n(h_n) = n \times 2\pi R_{min} \times \frac{h_n}{m} = .16n \times \frac{h_n}{m} \mathrm{m}^3$$

This gives energy gain

$$E_n(h_n) = nE_1 \times \frac{h_n}{m}$$
, $E_1 = \rho_T V_1(h/m = 1) = .7 \times 10^2 \text{ J}$.

The total energy transferred would be

$$E_{tot} = \sum_{n < n_{max}} E_n(h_n) = \sum_{n < n_{max}} n \times \frac{h_n}{m} \times .7 \times 10^2 \text{ J}$$

The order of magnitude looks reasonable and could explain considerable fraction of the energy needed for acceleration.

4. One can estimate from the empirically determined power feed the needed power feed if power comes from thermal energy alone. A rough estimate for the total energy transfer is as $E = \int P dt = \langle P \rangle T$, where T is the duration of the period of accelerated motion and $\langle P \rangle$ the average power. P was in the range 1-7 kJ/s. Equating the estimated total energy E with the estimate $E = \sum E_n(h)$, one obtains a rough estimate for the parameters if thermal energy alone is enough.

13.5.4 About the scaling of the system

The system of Roschin and Godin is rather massive and a natural question is whether it could be scaled down or made less massive otherwise.

1. Consider first the geometric scaling. If the interpretation of 10 Hz frequency as cyclotron frequency assignable to Fe ions, which can appear as dark ions in $B_{end} = 0.2$ Gauss is correct, then it would seem that the frequencies involved should scale down. This would mean geometric scaling of both radii and possibly also heights of the magnets.

For instance, scaling by factor x = 1/10 would produce stator radius R = 5 cm and rollers with radius $r = 5/12 \simeq .42$ cm for N = 12. The single basic unit at roller circumference would have length $2\pi r/N = \times 10\pi/N^2 = 10\pi/144 \simeq .22$ cm, which is rather small value.

2. What about the scaling of magnetic fields? The magnetic field strength is about 1 Tesla originally. The distance between magnetic walls is about .5 m and corresponds to the radius of stator, which is very natural. On the other hand, if the monopole part of B = .05 Tesla for walls is 2/5 of B as in case of B_E , the distance between magnetic walls would be cyclotron wavelength .5 m of electron. If the monopole fraction of 1 Tesla magnetic field is also 2/5, cyclotron wavelength would be 2.5 cm whereas the thickness of flu walls is 5-6 cm.

If one requires that cyclotron wavelength of electron corresponds to the stator radius, then one should scale B by the inverse of the same factor for lengths. This would for scaling factor 1/10 mean B = 10 Tesla not easy to realize. 1 Tesla seems to be upper bound for the field strength of commercially available magnets (http://tinyurl.com/q286tm4) and 50 Tesla the maximum field strength achieve in lab (http://tinyurl.com/y91gk6qr). Maybe the reason for the massive size of the magnetic system is just this.

3. One might think of curing the situation by using a hollow cylindrical stator of same or even larger radius to reduce B. As argued, the structure of MB of stator could consist of very long dipole flux loops rotated by 2π to get flux walls having torus topology and located inside each other. The walls would correspond to a slicing of the stator by hollow cylinders inside each other.

If the total flux is conserved and the number of walls is N and they have same thickness and field strength, one has

$$B\pi R^2 = B_{wall} \sum 2\pi R_n d = B_{wall} \sum_{0}^{N} n \times 2\pi R d = \frac{N(N+1)}{2} B_{wall} 2\pi R d$$
.

This gives for the number of walls

$$N(N+1) = \frac{B}{B_{wall}} R d \ .$$

For $B/B_{wall} = 20$ and R/d = 10 this would give N(N+1) = 200 and $N = 1/2(-1+\sqrt{801}) \simeq 13.6$. The number N of walls would be about 13. Replacing stator with a cylinder of radius 5 cm would still give single wall at distance of .5 m.

If the dark matter at magnetic walls extracts thermal energy from environment, the energy feed to the system would be reduced but this need not be fatal concerning if one is interested only in the demonstration and study of the effect using less massive system.

13.6 Appendix: Classical model fails

One can wonder whether the accelerated rotation could be explained in terms of Maxwell's theory. Could the transfer of energy, momentum, and angular momentum from classical fields to the rotating system allow to understand the acceleration rotation? The basic formulas for the stress tensor of Maxwell field in non-relativistic formalism are given at http://tinyurl.com/ztdskmp and help to understand the following.

Consider first the static fields.

- 1. External voltage sources is used to generate a radial electric field E corresponding to voltage of 20 kV, which presumably correspond to voltage difference between the stator and ground. This field would be in reasonable approximation $1/\rho$ as function of transversal distance from the stator origin. There are also a vertical magnetic fields associated with the rollers giving rise to rotor. The strength of this field is estimated to be of order .5 Tesla.
- 2. If the system is closed the energy momentum from the em fields can be transferred to the magnetic system and the total rate for these quantities for em fields equals to the negative of that for the magnetic system. It is enough to calculate what happens for energy momentum tensor of em field.

Energy momentum tensor $T^{\alpha\beta}$ for em field can be expressed in terms of its 3-D projection T^{ij} - stress tensor and $T^{ij} \equiv S^j$ and knowns as Poynting vector, whose components are given by the cross product $S = E \times B$ represents energy flow per surface area in its one direction. Now the direction is azimuthal. Flow lines of energy current rotate around the stator.

The divergence of em stress tensor integrated over surface S bounding a volume V gives the sum of total force f experienced by the matter in the volume V and of change of the momentum of the em field inside V given by the integral of $\partial S/\partial t$ over V. The flow of energy momentum from radiation fields to the volume can be calculated from the knowledge of fields outside the roller and stator.

The flux of the momentum from the system is given by the flux defined by the stress tensor over the surface. Stress tensor T^{ij} has a component analogous to pressure and magnetic and electric contributions of form $B^i B^j$ and $E^i E^j$. In the approximation that pressure term is constant within roller, the pressure contribution vanishes. This is not quite true for electric field and the resulting small net force is radial and vanishes at the limit when roller is very thin. For magnetic field the flux integral vanishes and for electric field one can have small radial force. No torque is obtained. Therefore Maxwell's theory cannot explain the claimed "antigravitational effect" in terms of transfer of momentum from em field to the system.

3. One can also calculate directly the rate for the transfer of angular momentum from em field to the magnetic system. One has $dJ^i/dt = \epsilon_{jk}^i \int dS_k (x^i T^{kj} - x^j T^{ki})$. Here integral is over the surface of each roller cylinder since only rollers are allowed to rotate. Pressure term in energy momentum tensor proportional to δ^{kj} gives by rotational symmetry of the roller a vanishing contribution. Magnetic term vanishes identically at the surface of the cylinder. Also electric field gives identically vanishing contribution.

The presence of magnetic walls of thickness about 5 cm suggest the possibility of standing em waves with momentum in the radial direction and wavelength of order .5 meters. These waves are oscillating and this implies that the possible transfer of energy, momentum, and angular momentum over the period of oscillation vanishes. One can also perform calculations similar to those above for standing waves with radial electric field and vertical magnetic field and wave vector in radial direction to find that also now the transfer of angular momentum is vanishing. There can be small transfer of momentum in radial direction to a roller. One can consider the situation also for longitudinal standing wave but now the transfer of longitudinal momentum is vanishing by the standing wave property.

The conclusion is that Maxwell's theory does not explain the reported findings.

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Chapter 14

Life-like properties observed in a very simple systems

14.1 Introduction

I encountered in FB a link to a rather interesting article by physicists working in Emory University. The title of the popular article was "*Physicists show how lifeless particles can become 'life-like' by switching behaviors*" (see http://tinyurl.com/y8wrz9ho).

The article "Emergent bi-stability and Switching in a Nonequilibrium Crystal" by Guram Gogia and Justin Burton is published in PRL and can be found in ArXiv [I79] (see http://tinyurl.com/ychho418). Justin Burton leads a physics group working at Emory University. Guram Gogia who made the discovery is her student.

The physicists working in Emory University have made very interesting discovery. The very simple system studied exhibits what authors call self-organized bi-stability making phase transitions between crystal-like and gas-like phases. The expectation was that only single stable state would appear. Neuron groups can also have collective bi-stability (periodic synchronous firing). Neurons are however themselves bi-stable systems: now the particles are plastic balls and are not bi-stable. One could say that the system exhibits life-like properties. The most remarkable life-like property is metabolism required by the sequence of phase transitions involving dissipation.

Where does the metabolic energy come from? The proposal of the experiments that stochastic resonance feeds the needed metabolic energy leaves open its source. The resemblance with living cells suggests that the attempt to interpret the findings solely in terms of non-equilibrium thermodynamics might miss something essential - the metabolism.

TGD provides a general model for living systems relying on the notion of magnetic body (MB), hierarchy of Planck constants $h_{eff} = n \times h$ labelling phases of ordinary matter identifiable as dark matter, and the realization of control and communication signals between MB and biological body using dark photons [K99, K98]. Bio-photons would result in the transformation of dark photons to ordinary photons and EEG would rely on dark cyclotron photons and generalized Josephson photons from cell membrane (also bio-photons would relate to them). Bose Einstein condensates of dark variants of biologically important ions or their Cooper pairs are also in a central role. The assumption $h_{gr} = h_{eff}$, where h_{gr} is so called gravitational Planck constant, implies that the energy spectrum of dark cyclotron photons is universal (no dependence on the mass of ion) and naturally in visible and UV range characterizing molecular transition energies. [K95, ?].

One can develop a detailed TGD inspired model for the findings leading to an identification of new control tools of MB (MB). Quantum criticality makes it possible for MB can adapt to the biological body (BB) so that it can generated cyclotron frequencies, which correspond to the characteristic frequencies of BB: forced oscillations serve as a control tool of MB. Also the analogs of Alfwen waves identifiable as analogs of string vibrations allow to control the systems at the nodes of the flux tube network.

In the system studied the crystal-like phase corresponds to a connected flux tube network associated having plastic balls as nodes, and gas-like phase to a totally disconnected network with connecting flux tube pairs split into flux loops. That freezing would require energy (going to the magnetic energy of flux tube network in h_{eff} increasing phase transition) does not conform with the thermodynamics of classical systems. That superfluid Helium has similar strange feature at low enough temperatures suggests that the system is indeed quantal. Cyclotron Bose-Einstein (BE) condensates of Cooper pairs of Ar^+ ions, protons, and electrons are proposed to be relevant. Encouragingly, the ratio of frequencies for horizontal and vertical oscillations frequencies of crystallike structure is equal to the ratio of cyclotron frequencies for Ar^+ and proton.

One of the key challenges is to identify the the prebiotic source of metabolic energy. The sequences of dark protons identifiable as dark nuclei give in TGD framework rise to analogs of DNA, RNA, tRNA, and amino-acids [K60, K62] [L44]. The model predicts the degeneracies of vertebrate genetic code correctly. In TGD based model for "cold fusion" as dark nucleosynthesis (DNS) serving as a precedessor of ordinary nucleosynthesis dark nuclei transform to ordinary nuclei liberating almost all nuclear binding energy [K31] [L64]. Dark analogs of DNA, RNA, tRNA, and amino-acids would therefore provide also the sought for prebiotic source of metabolic energy in the system studied: the egg-or-hen problem about whether the genes or metabolism came first, would be resolved.

Second very simple system exhibiting life-like properties consists of particles with a feed of acoustic energy at single wavelength. What happens is that the distribution of particles develops synchronous oscillations in wave length band below the acoustic wavelength. The oscillation amplitudes are reduced in this band so that wavelength gap emerges. The system is also able to heal. The interpretation is in terms of the emergence of flux tube structure rigidifying the system to pseudo-crystal. The energy of the oscillations of the particles is transferred to MB where it gives rise to Alfwen waves with a wavelength band analogous to atomic energy bands.

There is also a third such simple system demonstrating life-like properties. A research group in Aalto yliopisto led by professor Olli Ikkala has published an interesting article with title "*Programmable responsive hydrogels inspired by classical conditioning algorithm*". What is observed that a system consisting of hydrogel and Gold nanoparticles can get conditioned when it is heated in the presence of irradiation at blue and red wavelengths. Conditionin means that the system melting under heating learns to melt in the presence of only irradiation. The experimenters assume that the Gold nanoparticles forming chains during heating serve as a memory element in the learning.

A simple TGD based quantum model for the conditioning relies on TGD inspired general model of living systems extended recently to a model of quantum self-organization in which energy feed serving as metabolic energy feed induces generation of dark matter as $h_{eff} = nh_0$ phases of ordinary matter at the magnetic body of the system. In number theoretic vision the presence of these phases correspond to higher algebraic complexity and higher "IQ".

The light signal would generate Pollack effect, which in TGD framework means transfer of protons from photo-acids to dark $h_{eff} = nh_0$ protons at magnetic flux tubes parallel to nanoparticle chains. The "IQ" of the system or its magnetic body characterized by h_{eff} would increase and it would become able to self-organize. The energy from the heating would be stored to the nanoparticle chains taking the role of proteins as energy storage. Melting would be a self-organization process increasing complexity, and in absence of heating (and perhaps even in its presence) the gel phase would receive the energy needed from the nanoparticle chains. The conditioning in this sense would not be a passive mechanical response. The system would be macroscopic quantum system, and the energy feed would make possible for it to evolve to a higher level of complexity and conscious intelligence.

14.2 Basic ideas of TGD inspired quantum biology

TGD Universe is quantum critical and quantum criticality involves universal dynamics. This raises the hope that also the TGD inspired model of living systems is universal and applicable also in the recent context. The findings would provide a test for TGD view and even allow to sharpen it. TGD based view about living systems involves several new notions.

14.2.1 Dark matter as hierarchy of phases of ordinary matter with $h_{eff} = n \times h$

The first new element is the hierarchy of Planck constants $h_{eff}/h = n$. In adelic physics [L74, L75] proposed to provide physical correlates of both sensory experience and cognition $h_{eff}/h = n$ serves as a kind of IQ for the system measuring its algebraic complexity (*n* could correspond to the order of the Galois group for the extension of rationals defining the adele in question).

1. Quantum criticality is the basic property of TGD Universe and also an essential aspect of what it is to be living in TGD Universe and the associated long range fluctuations and correlations correspond to large values of $h_{eff}/h = n$ for the flux tubes of MB [?]. The increase of $h_{eff}/h = n$ keeping magnetic field strength un-affected reduces binding energies for electrons of atoms and increases cyclotron energy scale and scales up quantum lengths and times, in particular the scales of quantum coherence and this kind of phase transitions seem to be crucial in TGD inspired biology.

The energies of subsystems indeed typically increase with h_{eff} . For instance, atomic binding energies are proportional to $1/h_{eff}^2$. Cyclotron energies are in turn proportional to h_{eff} .

The function of metabolism in TGD Universe is to increase the value of h_{eff} for some subsystems of living system, and therefore to increase the complexity of the subsystem. The reduction of h_{eff} liberates energy and this energy could kick the reacting molecules over the potential wall in bio-catalysis. The reduction of *n* forcing the shortening of the flux tubes could provide a mechanism allowing the reacting biomolecules to find each other in a dense molecular soup.

2. The cyclotron frequencies of dark ions in the magnetic field of the flux tubes do not depend on $h_{eff}/h = n$ but the cyclotron energies $E_c = h_{eff} \times f$ are scaled up by factor n so that they are above thermal energy at physiological temperatures and can carry information so that they can be used for communication and control purposes. Cell membrane acts as a generalized Josephson junction and dark Josephson radiation communicates sensory information to MB coded to the modulation of the generalized Josephson frequency by the variations of neuronal membrane potential induced by nerve pulse patterns [K103, K48].

14.2.2 $h_{qr} = h_{eff}$ hypothesis and universal cyclotron energies

 $h_{gr} = h_{eff}$ hypothesis [K95, ?] and its generalizations such as e $h_{em} = h_{eff}$ represent a further key element of the TGD inspired model of living matter. This relationship is proposed to hold when the coupling strength proportional to appropriate charges is so large that perturbation series does not converge. The large value of h_{eff} reduces the value of coupling strength proportional to $1/h_{eff}$ so that dark matter satisfying this condition would allow a perturbative description.

1. Nottale [E1] introduced originally the notion of gravitational Planck constant $\hbar_{gr} = GMm/v_0$ to explain the orbital radii of planets in solar system as Bohr orbits. The value of the velocity parameter v_0/c is of order $2^{-11} \simeq .5 \times 10^{-3}$ for the inner planets. The interpretation in TGD framework is that the magnetic flux tubes mediate gravitational interaction between masses M and m and the value of Planck constant is h_{qr} at them.

The proposal $h_{eff} = h_{gr}$ at flux tubes is very natural sharpening of the original hypothesis [?, K95]. The predictions of the model do not depend on whether m is taken to be the mass of the planet or any elementary particle associated with it and the gravitational Compton length $\lambda_{gr} = GMc/v_0$ does not depend on the mass of the particle, and is proportional to the Schwartschild radius $r_S = 2GM$ of Sun. This encourages the idea about astroscopic quantum coherence at magnetic flux tubes mediating gravitational interaction. One of the applications is to the fountain effect of superfluidity [?].

In the biological applications the identification of mass M as Earth mass is one possibility but there are also other options [K95]. The identification of v_0 as some mechanical velocity scale looks natural. 2. $h_{gr} = h_{eff}$ hypothesis predicts that cyclotron energies do not depend on the mass of the particle whereas cyclotron frequencies are proportional to 1/m. Cyclotron energy spectrum would be universal and correspond to the spectrum of magnetic field strengths B. Biophotons with energies in visible and UV are proposed to result as dark photons satisfying $h_{gr} = h_{eff}$ transform to ordinary photons. For $B = B_{end} = 2B_E/5$ ($B_E = .5$ Gauss is the nominal value of the Earth's magnetic field) the hypothesis fixes the scale of cyclotron frequencies and h_{gr} should be in the range $10^{12} - 10^{14}$.

14.2.3 MB (MB) and its motor actions

A further new element is the notion of MB (MB) adding to the pair formed by organism and environment a third member. This brings into biochemistry a radically new element [K99, K98]. One can say that MB uses biological body as a motor instrument and sensory receptor.

- 1. In TGD standard model gauge fields and gravitational field are replaced locally by the 4 embedding space-time coordinates behaving like field variables. This implies an enormous simplification of the local dynamics however lost in the QFT limit replacing many-sheeted space-time with a slightly curved region of M^4 . A further simplification comes from preferred extremal property [K14, L76, L66].
- 2. At the level of space-time topology the situation becomes however extremely complex. Gauge fields created by the system are replaced with field body consisting of topological field quanta (space-time sheets) so that one can assign to a system well-defined field identity field body. One has a fractal hierarchy of field bodies within field bodies. Magnetic flux quanta represent one example of topological field quantization.

System has therefore besides its biological body (BB) also MB (MB) carrying dark matter particles identified ordinary particles with scaled up Planck constant $h_{eff}/h = n$ implying scaling up of various quantum length and time scales (by factor n in the simplest situation). MB has a hierarchical onion-like structure corresponding to various p-adic length scales and various values of h_{eff} .

MB can control BB by "motor actions" in which the length L and possibly also the area S of flux tubes change [K99]. This affects string tension and amplitude of oscillations of systems connected by magnetic flux tubes so that motor action of BB is induced. The phase transition changing the field strength could be induced by a phase transition changing h_{eff} : if magnetic flux is monopole flux it is conserved. There are two options.

1. The scaling $(S, L) \to n \times (S, L)$ leaves L/S invariant and scales down the magnetic field strength as $B \propto 1/S \to B/n$. Magnetic energy and cyclotron energies are unaffected but cyclotron frequencies f_c scale down as $f_c \to f_c/n$. There is quantum criticality corresponding to flux tubes with same value of L/S in the sense that these systems have same energies. This kind of quantum criticality could occur at critical values of relevant parameters.

Quantum criticality makes it possible for MB to tune its cyclotron frequency spectrum so that it corresponds to a given set of frequencies associated with BB. MB can control the corresponding oscillatory processes at BB by using dark cyclotron radiation transformed to bio-photons as a resonant driving force. Dark cyclotron radiation would result from the decay of dark cyclotron BE condensates. MB would thus adapt to the properties of BB. The larger the maximal value of n, the wider the variety of different adaptations, the higher the ability of the system to survive, and the higher the evolutionary level of the system.

The cyclotron energy spectrum associated with EEG could also entrain to various frequencies assignable to the neural circuits and in this manner MB would gain a control over them. Entrainment occurring at the level of brain would be second example of this process. MB learns to mimic the processes occurring at the level of BB and in this manner gains control over them. MB also learns how to get information about them. The motor actions of MB allowing to change the thickness and length of the flux tubes would be essential for achieving this.

Remark: In the case studied the frequencies f_V and f_H assignable to the oscillations of plastic balls would correspond to frequencies at level of BB to which MB tunes by a suitable choice of h_{eff} .

2. For $(S, L) \rightarrow (S, n \times L)$, magnetic field remains invariant so that cyclotron frequencies are unaffected. Magnetic energies and cyclotron energies are scaled up by n: one might say that one has criticality in classical sense. This kind of transitions require energy and are analogous to first order thermodynamical phase phase transitions.

Remark: In the case studied the phase transition from gas to crystal-like phase of plastic balls would correspond to the increase of h_{eff} leaving the frequencies invariant and would thus require energy in contrast to the usual view that energy is liberated in freezing (Helium superfluids are the only exception to the rule, and are macroscopically quantum coherent systems).

- 3. The decay of cyclotron BE condensates at MB generates dark cyclotron radiation, which can transform to ordinary radiation and drive oscillatory processes at BB [K20, L28]. This provides an additional control mechanism. Dark photons can transform to ordinary ones in several ways. The following special cases are diametric opposites of each other and correspond to $n \leftrightarrow 1$ transitions. More general transitions are of type $m \leftrightarrow n$.
 - (a) Dark photon with energy $E = h_{eff} \times f$ can transform to ordinary photon with same energy and frequency $n \times f$. Bio-photons would result from low frequency dark photons - even dark EEG photons - in this manner. Bio-photons are in visible and UV range and biomolecules have excitation energies in this range so that MB could control biochemistry in this manner.
 - (b) Dark photons with energy $E = h_{eff} \times f$ can decay to a bunch of *n* ordinary photons with the same frequency *f* but energy E/n. This could allow MB to control electromagnetic and mechanical oscillations taking place at low frequencies.

Also transformation which reduce Planck constant but do not lead to n = 1 state are possible.

Remark: In the case studied the decay of BE condensates to ordinary ELF photons could allow the control of the oscillations of plastic balls.

4. Alfwen waves (see http://tinyurl.com/7ekxqt2) are part of the dynamics of ordinary Maxwellian magnetic field often described phenomenologically as oscillations of magnetic flux tubes. The phase velocity $v = c/\sqrt{\epsilon}$ is light velocity in vacuum modified by the dielectric constant $\epsilon = 1 + \rho/B^2$ (one has c = 1, $\epsilon_0 = 1$, and $\mu_0 = 1$ in the units used) caused by the total mass density of charged matter and energy density magnetic field.

Alfwen waves generalize in TGD framework to oscillatory perturbations of the magnetic flux tubes, which in 1-D approximation for flux tubes can be modelled by transversal vibrations of string characterized by string tension proportional to L/S. In longitudinal directions the vibrations are in the interior of string trivial but induce oscillations of the distance between the ends of the string and are thus visible in the dynamics of BB.

Remark: In the recent situation Alfwen waves would naturally affect the dynamics of plastic balls in the crystal-like phase if flux tubes connecting the plasma balls are present.

5. The motor actions of MB can also change the topology of MB. BB is assumed to posses closed U-shaped flux tubes acting as kind of tentacles scanning the environment and re-connecting with the U-shape flux tubes associated with other systems to form pairs of flux tubes connecting two systems [K62, K68, K69]. These reconnections would serve as a topological correlate for a directed attention and for entanglement between the systems at the ends of the flux tubes. For instance, immune system would have developed from this kind of scanning of the environment.

One can imagine even more radical magnetic "motor actions". At given level of hierarchy of space-time sheets space-time sheets of sub-systems can be connected by a network of magnetic flux tubes [L51]. The connectedness of the flux tube network can change by the re-connection process and its reversal. The increase of h_{eff} affects the size of the closed loops

and can induce their reconnections to flux tube pairs connecting the systems at its ends. The reduction h_{eff} can induce the reversal of reconnection and split the flux tube pair to two flux loops. This gives rise to quantum analogs of phase transitions between crystal-like and fluid-like phases.

Remark: In the case studied the formation of crystal phase from plastic balls could correspond to the re-connection of flux loops assignable to plastic balls to form kind of tensor network correlating the dynamics of plastic balls. Its reversal would lead to gas phase.

14.2.4 Dark nucleosynthesis (DNS) as a source of metabolic energy in prebiotic systems?

One of the key challenges is to identify the prebiotic source of the metabolic energy. The sequences of dark protons identifiable as dark nuclei give in TGD framework rise to analogs of DNA, RNA, tRNA, and amino-acids. In TGD based model for "cold fusion" as dark nucleosynthesis (DNS) proposed to serve as the precedessor of ordinary nucleosynthesis these dark nuclei transform to ordinary nuclei liberating almost all nuclear binding energy [K31] [L64]. DNS could provide the sought for prebiotic source of metabolic energy and also a source of metabolic energy in the system studied.

1. There is a considerable evidence for the production of energy in what is known as "cold fusion" not allowed by the standard nuclear physics [L38, L64]. As a matter of fact, cold fusion is definitely *not* in question, which has motivated the introduction of the term low energy nuclear reactions (LENR). What definitely occurs are nuclear transmutations, that is formation of nuclear isotopes not present in the original system. Also energy is produced [C7, C6].

The typical experimental arrangement involves electrolysis in which one has a voltage between electrodes inducing the ionization of hydrogen or deuterium. The positive ions flow towards the negatively charged cathode and the transmuted elements appear at the cathode and also heat is produced. Now one has negatively charged electrode and also plastic balls are negatively charged being thus analogous to cathode with a negative surface charge. Ar^+ ions could take the role of protons or deuterium ions. Also protons could be present.

2. I have been recently working with a detailed model for "cold fusion" [L38, L64] [K31]. In Widom-Larsen model (WL) [C2, C9] to LENR only standard model of nuclear interactions is used but some unrealistic looking assumptions must be made. Remarkably, there is also evidence that the transmutations take place also in living matter [C3, C8] and the question is whether nuclear transmutations could provide a new source of metabolic energy.

TGD based model involves new physics and relies on DNS involving the formation of dark proton sequences at magnetic flux tubes of MB of the system [L38]. Dark proton sequences would be dark nuclei and would suffer rapidly occurring dark beta decays replacing some dark protons with dark neutrons. Dark nuclei would transform to ordinary nuclei and liberate almost all of ordinary nuclear binding energy in the process. Most of the energy could go to the magnetic flux tubes possibly leading out of the system and would be lost. The flux tubes entering to the negatively charged surfaces such as some regions of cathode would be an exception.

Could stable light nuclei fuse to heavier ones by forming dark nuclei consisting of weakly bound ordinary nuclei transforming to ordinary nuclei also in living matter? If dark weak decays are not involved, both (A, Z) are additive in the process. If dark weak decays are allowed, only Ais additive. If these fusion reactions produce the biologically important ions, A and possibly also Z for the nuclei of biological ions would form an additive group with some basic nuclei serving as generators.

1. If proton is taken as an additive generator, the situation is trivialized. On the other hand proton, is not a genuine nucleus, and ordinary nuclei of form A = Z are also unstable. It is however to add dark protons to an ordinary nucleus at magnetic flux tubes to get $(Z, A) \rightarrow (Z + 1, A + 1)$ suggested by Widom and Larsen to be a basic process. Dark proton could suffer dark weak decay with a scaled up rate since dark weak bosons are effectively massless below the size scale defined by their scaled up Compton length. This mechanism is central in both WL model of LENR and in TGD based model of DNS [L64].

- 2. He(2, 4) is the basic product in DNS and because its large binding energy would be a natural generating nucleus. The resulting nuclei would have $(Z, A) = n \times (2, 4)$. A is always even for these nuclei. The nuclei C, O, Ne, Mg, S, Ar, Ca are all stable and correspond to n = 3, 4, ..., 10. C, O, Mg, S, Ca are of central importance in living matter. Be(4, 8) with n = 2 is missing from the list. The reason is that it has very short life-time against alpha decay whereas energy conservation prevents alpha decays of the heavier nuclei in sequence.
- 3. D(1,2) is the lightest non-trivial candidate and would give nuclei of form $(Z,A) = n \times (1,2)$. The binding energy of D is however rather small. The nuclei formed as multiples of He(2,4) can be formally regarded as even multiples of D(1,2) (only formally, because the binding energy per nucleon for He(2,4) is considerably larger than for D(1,2)). The odd multiples correspond to stable isotopes Li(3,6), B(5,10), N(7,14) corresponding to n = 3,5,7. F(9,18) decays to stable O(8,18), Na(11,20) decays to stable Ne(10,20), and Al(13,26) to stable Mg(12,36). This reflects the fact that for stable heavier isotopes the number of neutrons is larger than number of protons.
- 4. Li(3, 6) is stable albeit not the most abundant isotope of Lithium. C, F, Mg, P, Ar have isotope of form $n \times (3, 6)$ with n = 2, 3, ..., 6. Most of these nuclei are obtained from He(2, 4). The isotopes F(9, 18) and P(15, 30) are unstable and decay by beta decay to stable O(8, 18)and Si(14, 30) respectively.
- 5. One can also form sums of different nuclei: $(Z, A) = (Z_1, A_1) + (Z_2, A_2)$.
 - (a) The simplest sum corresponds to $(Z_2, A_2) = (1, 2) = D$. This addition is especially natural for nuclei which are multiples of He(2, 4). This allows to transform isotopes H(2, A) to Li(3, A + 2) and Li(3, A) to Be(4, A + 2), Be(4, A) to B(5, A + 2), B(5, A)to C(6, A + 2), C(6, A) to N(7, A + 2), and N(7, A) to O(8, A + 2). O(8, A) cannot be transformed to a stable isotope F(9, A + 2).
 - (b) The addition of dark proton to a stable nucleus ((Z + 1, A + 1) = (Z, A) + p is the key mechanism of WL model and conforms with the basic vision about the DNS as formation of dark proton sequences and addition of dark protons to an ordinary nucleus at the flux tube.

For instance, one has Na(11, 23) = Ne(10, 22) + p, P(15, 31) = Si(14, 30) + p, S(16, 31) = P(15, 30) + p, Cl(17, 35) = S(16, 36) + p, K(19, 39) = Ar(18, 38) + p, and Mn(25, 44) = Cr(24, 54) + p). All nuclei except P(15, 30) appearing in the initial state are stable. P(15, 20) suffers (perhaps dark) beta decay to Si(14, 30), which is stable. This however does not prefer the addition of proton to take place.

Fe(26, 56) is an important biological ion and could be obtained from Fe(26, 52) by an addition of four dark protons with subsequent dark weak decays of proton to neutron. Fe(26, 52) is unstable against beta decay to Mn(25, 52) in turn unstable about beta decay to Cr(24, 52), which is stable.

(c) One can consider also sums of heavier isotopes. For instance, the sums K(19, 39) = O(8, 16) + Na(11, 23) and Ca(20, 40) = O(8, 16) + Mg(12, 24) are stable biologically important nuclei obtained as sums of stable biologically important nuclei. Biologically important nuclei Na(11, 23), P(15, 31), S(16, 31), Cl(17, 35), K(19, 39), Mn(25, 55) have odd value of A so that they are not obtained as sums of the nuclei constructed using the rules discussed above.

To sum up, that the nuclei obtained as multiples of He(2, 4) correspond to several biologically important nuclei can be seen as an indication that dark fusion of at least He(2, 4) nuclei takes place in living matter.

14.3TGD based explanation for the life-like aspects of the system consisting of plastic balls

14.3.1Experimental findings

The news [I79] is that the system studied exhibits what authors call self-organized bi-stability making phase transitions between crystal-like and gas-like phases. The expectation was that only single stable state would appear. Neuron groups can also have collective bi-stability (periodic synchronous firing). Neurons are however themselves bi-stable systems: now the particles are plastic balls, which are not bi-stable systems. One could say that the system exhibits life-like properties. The most remarkable life-like property is metabolism required by the sequence of phase transitions involving dissipation. Where does the metabolic energy come from?

The durations of the switching time scales are shorter than stable periods and also shorter than predicted by the simulation. The presence of periodicity perturbation, presumably the period for the oscillating phase transition, is suggestive and authors conjecture that there is a weak but vet unidentified periodic signal present required by the proposed stochastic resonance model.

Let us consider first in some detail what the system is and what happens in it.

- 1. The system studied consists of small charged plastic balls of radius nearly 10 μ m (cell size scale) in a cold atmospheric plasma consisting of Argon ions (Ar^+) (see http://tinyurl. com/yc7q617o). The charged plastic balls consist of melamine formaldehyde (MF) polymers. The plasma is generated using a voltage between electrode and Earth leading to the ionization of Ar to Ar^+ : the typical value of voltage is 6 Volt. The electrons from Argon atoms provide negative charge for the plastic balls.
- 2. Negatively charged BF balls are levitated above the electrode having negative charge given by Q = CV, where C and V are the geometrically determined capacitance and the voltage of the ball. In equilibrium position gravitational and electrostatic forces compensate each other when the size of the ball in certain range. Too heavy balls fall down to the electrode and lighter balls levitate and form a cloud, whose thickness is determined by the variation of the radius of plastic balls. BF balls have mutual repulsive action. The negative charge of the balls is screened by Ar^+ ions with screening characterized by Debye length $\lambda_D \sim 1$ mm. There is also a gradient in the density of Ar^+ ions attracting the balls near the centre of the electrode. The situation is modelled in terms of confining harmonic oscillator potentials in vertical and transversal directions.
- 3. A crystal-like phase is created by the horizontal confinement. In crystal-like phase collective synchronous oscillations in the vertical direction are initiated so that the equilibrium height of hexagonal plastic ball lattice oscillates. Oscillations are damped by dissipation. The oscillation frequency is determined by the sum of gravitational and electric interaction potentials. The variation c_V of the radius of the plastic ball induces a variation of the mass M and capacitance C and therefore also a variation of the oscillation frequencies f_V and f_H in vertical and transversal directions. The typical values of these frequencies are $f_V = 20$ Hz and $f_H = .5$ Hz. This implies that synchrony of oscillations is lost, and eventually a transition to gas-like phase takes place as nucleation centres for gas-like phase are formed. The gas-like phase dissipates its energy.

Remark: That the ratio $f_V/f_H = 40$ equals to the ratio of cyclotron frequencies of proton and Ar^+ serves as an important guideline in TGD inspired model.

4. The surprise was that for low pressures and low Ar^+ ion densities a transition to crystal-like phase takes place: this transition correspond to a critical value of the variation c_V for the plastic ball radius. Above the critical value of c_V the system remains in gas phase and below it in crystal-like phase. The crystal-like phase is collectively oscillating in vertical direction, which requires energy feed.

There is synchrony between the dynamics of plastic balls in crystal-like phase, which is lost and leads to a melting and loss of phase phase coherence between oscillations of plastic balls. Particle system was repeatedly melting and freezing.

5. Since the analog of crystal-like phase is repeatedly generated, there must be a feed of energy to the system analogous to metabolic energy feed in living systems. The proposal of the article is that the energy feed is due to a stochastic resonance [D9]. In stochastic resonance noise amplifies oscillatory signal fed into the system if its frequency f satisfies f = f(spont)/2, where f(spont) is the average frequency for the jumps between the bi-stable states of the system due to noise. Since the period of conjectured oscillation is $\tau \sim 100$ s one should have $\tau(spont) \sim 50$ s. The period for this process is considerably longer than for the vertical oscillations. The origin of this self-induced oscillation required by stochastic resonance model is not understood and one can even challenge its existence.

Remark: From the point of view of quantum biology it might be highly relevant that plastic balls consists of organic molecules. BF molecules involve aromatic 6-cycles appearing also in DNA. There is negative charge associated with the plastic balls. Also DNA carries negative charges associated with phosphate ions.

The system under study [I79] indeed has several features bringing in mind living cell as it is understood in TGD.

- 1. The situation is in some aspects analogous to that prevailing over the cell membrane. Cell membrane is analogous to a battery providing metabolic energy for the system via ATP-ADP process. Could the voltage between electrodes creating Ar^+ plasma have analogous function? It seems however that DNS is the what provides the metabolic energy. Ar^+ could be analogous to biological ions such as K^+ . The negative charges from Ar atoms are received by plastic balls or even the space-time sheet containing them.
- 2. Charged plastic balls consisting of melamine formaldehyde (MF) polymers are somewhat analogous to biomolecules such as DNA sequences, which also carry negative charge. The charged plastic balls consisting of MF (see http://tinyurl.com/z532ryv) are organic matter. MF contains aromatic 6-cycle appearing also in important biopolymers such as RNA and DNA. Perhaps the plastic balls are not so simple systems as the non-equilibrium thermodynamics based model of experimenters assumes. Could their molecular structure have something to do with the observed life-like aspects of the system? In particular, could the molecular structure make possible the generation of dark proton sequences at flux tubes?
- 3. The system dissipates and must receive metabolic energy from some source. The metabolic energy feed seems to take place with average period τ of about 100 s. Stochastic resonance requiring periodic oscillation amplified by the stochastic signal is not the only possible explanation. In TGD inspired quantum biology metabolic energy feed induces increase of h_{eff} . The increase of h_{eff} would increase the scale of quantum coherence and make the system crystal-like so that the plastic balls oscillate in synchrony. DNS provide an obvious candidate for the origin of the metabolic energy.

These observations motivate a quantum approach different from the approach based on non-equilibrium thermodynamics and stochastic resonance.

14.3.2 Self-organized bi-stability or oscillations driven by cyclotron radiation and energized by DNS?

The theoretical approach of the experimenters relies on the notions used to describe far-fromequilibrium systems using generalization of thermodynamics. The vision is that the dynamics of complex systems has universal features. Conservative force (gravitational force and electric forces between plastic balls and electrodes and plastic balls), dissipation and stochastic force would be present.

Remark: No driving force is assumed: this would describe the damped oscillations but cannot explain the repetition of the phase transitions.

Stochastic resonance would feed metabolic energy to the system inducing the jumps over potential wall making possible the transitions between the two phases, amplify the vertical and horizontal oscillations, and also give kinetic energy for the plastic balls in gas-like phase.

The summary of the article gives a technical description of the discovery.

The experiments and simulations presented here display a broad class of non-equilibrium phenomena in a single system with minimal ingredients and rich dynamics. We have experimentally demonstrated global bi-stability in a spatially-extended system com- posed of non-bi-stable elements. Given the underlying first-order phase transition between the condensed and gas-like phases, our experiment may be a realization of self-organized bi-stability. The inter-state switching is facilitated by both quenched disorder and dynamical noise. The time scales of individual stable and un-stable periods are not symmetric. Durations of instability are mostly determined by the damping time, whereas the stability durations can be much longer and depend on the nucleation of an energy-redistribution event. This is a common property in many excitable systems, where the relaxation path is more deterministic than the excitation path. However, the distribution of switching timescales in the experiment is narrower than in the simulation. This may be due to a weak periodic signal in the experiment which couples with the noise to induce switching. The source of the periodicity, in addition to controlling the vertical oscillations through modulating the electrode voltage, are subjects of current investigation in our lab.

In the sequel the model is analyzed to identify its possible weaknesses in order to see how TGD inspired quantum approach could allow to circumvent them.

Thermodynamical aspects

The authors assume that the transitions involved are analogous to first-order phase transitions (heat is absorbed or liberated and the transition occurs at constant temperature and regions of both phases are present) between condensed and gas-like phases. Could simple thermodynamical analogies for the transitions between condensed and gas-like phases help to understand the situation?

1. Melting and evaporation require usually heating. Enthalpy of fusion is the quantity describing the energy needed by the heating. It is usually positive (in liquid and gas phases molecules have larger thermal energy than in solid phase). Only for ${}^{3}He$ and ${}^{4}He$ superfluids at sufficiently low temperatures the enthalpy of fusion for melting is negative (see http://tinyurl.com/pfr84c3). Also in the recent situation the generation of the damped oscillations would suggest that the enthalpy of fusion is negative.

Positive enthalpy of fusion for melting requires that energy is fed into the system. It however seems that nucleation centres are generated by the variation of oscillation frequency and that the process occurs spontaneously and transfers energy from the degrees of freedom responsible for the bonding of balls to crystal-like phase to the kinetic energy of balls. Therefore the situation resembles that for Helium superfluid at low temperatures also in this respect. Some additional degrees should be present.

2. Could thermodynamical analogy help to understand what happens in the phase transition between gas-like and crystal-like phases. Freezing usually liberates heat but since heat correspond to completely disordered motion it seems highly implausible that this heat would go to the ordered collective motion of the crystal-like phase.

In heat engines the amount of heat transformable to work is by second law of thermodynamics below $\gamma = \Delta T/T_h$, where ΔT is temperature difference and T_h the higher temperature. To have synchronous oscillations due the liberated heat, looks highly implausible. If work is done, it must be done by additional degrees of freedom receiving energy and providing it as energy required by the excitation of damped oscillations of crystal-like phase. This option seems plausible.

If one wants to use thermodynamical analogies, it seems that one must assume that there are additional yet un-identified degrees of freedom and a yet un-identified source of energy pumping energy to these degrees of freedom.

The analogy with Helium supra phases

Consider now the analogy with Helium supra phases (see http://tinyurl.com/zs8rpjm and http://tinyurl.com/pfr84c3).

- 1. In TGD framework the obvious identification of the additional degrees of freedom is as those associated with magnetic flux tubes of MB forming a network in crystal-like phase. The flux tubes and the cyclotron BE condensates of ions at them would carry energy.
- 2. The generation of crystal-like phase would require energy. As noticed, this implies resemblance with He^3 , in which Cooper pairs give rise to a superfluidity suggesting that the system behaves as a macroscopic quantum system. Cooper pairs of Ar^+ ions could form an analog of super-fluid or super-conductor. Also Cooper pairs of electrons and protons coming from plastic balls could form super-conductors. In TGD framework the members of Cooper pairs would be located at parallel magnetic flux tubes connecting plastic balls [K26, K27, K100, K101].
- 3. In the transition to gas phase this network would be destroyed as the reconnections between MBs of plastic balls are split and give rise to nucleation regions for gas phase. The splitting would liberate magnetic energy and also energy of cyclotron BE condensates if the value of h_{eff} is reduced. This energy would transform to the kinetic energy of the plastic balls. Therefore the phase transition would liberate energy and would be analogous to the corresponding transition for ³He. Note that also the TGD based model for supra phases of Helium involves magnetic flux tube network [?].
- 4. The phase transition should change the values of $h_{eff}/h = n$ but leave cyclotron frequencies un-affected and thus involve energy feed so that first order phase transition would be in question.

The mechanism inducing vertical and horizontal oscillations of plastic balls

One should identify the mechanism giving rise to the vertical and horizontal oscillations of plastic balls.

- 1. The authors of the article [I79] propose an identification for the interactions involved. TGD approach suggests additional interaction due to the string tension of the flux tubes giving rise to elastic force and additional interaction energy. As already noticed, the model of authors does not assume resonant driving force although they mention of having tried it. The probable reason for giving up this option is that it allows only the decay of crystal-like phase to gas-like phase but not a repetitive cycle.
- 2. The ratio $f_V/f_H \simeq 40$ for typical vertical and transversal oscillation frequencies equals to the ratio $m(Ar^+)/m(p) \simeq 40$, which suggests that BE condensates of Cooper pairs of both Ar^+ and protons are indeed present at flux tubes. The condition that cyclotron frequencies are in question, fixes the value of magnetic field strength to $B = B_{end}/15$, where $B_{end} = 2B_E/5 = .2$ Gauss is an endogenous magnetic field assumed be important value of magnetic field in TGD inspired quantum biology and inspired by findings of Blackman and others [J23, J29]. $B_E = .5$ Gauss is the nominal value of the Earth's magnetic field.

p-Adic length sale hypothesis slightly favors the value $B = B_{end}/16$, which corresponds to the magnetic length $L_B = \sqrt{\hbar_{eff}/eB} = 4L_{B_{end}} = 22.8 \ \mu\text{m}$ (from $L_{B_{end}} = 5.7 \ \mu\text{m}$) to be compared with the size $d \simeq 10 \ \mu\text{m}$ of the plastic balls.

One can estimate also the classical cyclotron radii from the formula $r_c = mv/eB = p/QB$, where v is the velocity of the charged particle. For cyclotron orbits with principal quantum number n Bohr quantization gives $r_c = \sqrt{n}L_B$, where $L_B = \sqrt{\hbar/QB}$, is magnetic length. Note that orbits with same radius are possible for $h_{eff}/h = n_i$. i = 1, 2 if one has $n_1 = nn_2$ or vice versa.

3. This suggests a mechanism generating vertical and transversal and horizontal oscillations of the plastic balls. The cyclotron radiation resulting in the decay of the BE condensates drives the oscillations resonantly by oscillatory force $F = F_0 \times exp(i\omega t)$ so that one obtains the oscillation amplitude as a sum of damped oscillation amplitude $exp(-\Gamma t)exp(i\omega t)$ and resonance term proportional to $exp(-\Gamma t)exp(i\omega t)t$ increasing in oscillatory manner up to time value $t \sim 1/\Gamma$ and decreasing after that exponentially. The parameters F_V and F_H would be additional parameters in TGD based model.

Remark: This mechanism could be quite general mechanism of quantum biology.

- 4. The variation of the plastic ball radius induces a variation of mass and charge of the ball and therefore also a variation of the oscillation frequencies f_H and f_V , which can be however compensated by the variation of the magnetic field strength B at flux tubes inducing variation of string tension and elastic constant so that synchronous oscillations are possible. This is possible only for c_V below some critical value. For larger values the compensation is not possible, and the oscillations lead to gas phase. For smaller values the solid phase is stable. At (quantum) criticality the metabolic cycle becomes possible.
- 5. The oscillations of plastic balls could be induced by the analogs of Alfwen waves for the magnetic flux tubes which in 1-D approximation for flux tubes would be essentially vibrations of string characterized by string tension proportional to L/S. The energetics of the system would be invariant under changes of $h_{eff}/h = n$ if L and S scale like n, and one would have quantum criticality allowing MB to adapt to the properties of the plastic ball system. A network consisting of springs would provide an analog system. The decay of cyclotron BE condensates would feed energy to the vibrations of string in turn feeding energy to the oscillations of plastic balls. Both energy feeds could be modelled in terms of forced oscillations.

Quantum criticality would make possible for MB to adapt to the properties of the part of the system consisting of ordinary matter by a proper selection of n since one has $f_c \propto n$ for the same energetics. For given value of B different charged dark particles have different cyclotron frequencies but same energies at quantum criticality. Also the $h_{gr} = h_{eff}$ condition implies that the cyclotron energies do not depend on particle mass and therefore implies quantum criticality.

The energetics of the system

The energetics of the system demands an analog of metabolic energy feed.

- 1. Authors assume that stochastic resonance provides the needed energy feed but its origin remains open. Stochastic resonance requires an additional oscillator with period about $\tau = 100$ s. According to the authors, the problems of their model are that the transition periods seem to be too short and also the times spent in stable and transition states are not symmetric as they should be in bi-stable system. Also the prediction for the frequency $f = 1/\tau$ tends to be too short.
- 2. To get the metabolic cycle with forced oscillations without stochastic resonance, one needs a kick providing the energy inducing a phase transition to the crystal-like phase, which also oscillates as a whole thanks to this energy feed. In TGD framework the needed energy dose could be provided by dark nucleosynthesis (DNS) involving formation of dark proton sequences containing perhaps also Ar^+ ions and transforming to ordinary nuclei. The transition could be rather fast and occur in the minimal case only once during the single metabolic cycle of about $\tau = 100$ s so that one would have $\tau \sim 1/\Gamma$, where Γ is the average rate for DNS. Also the phase transition splitting the flux tube pairs by de-reconnection could be rather fast as compared to τ .

Remark: The periodic signal with frequency f = 1/100 Hz is not necessary.

3. Dark cyclotron radiation with $h_{eff}/h = n$ could transform to ordinary photons with energy, which is *n*-multiple of ordinary cyclotron energy. If *n* is large enough the photons have energies above thermal energy. In living matter the values of *n* are in the range $10^{12} - 10^{14}$ so that the cyclotron energies correspond to bio-photon energies in visible and UV range characterizing the transition energies of bio-molecules. If $h_{gr} = h_{eff}$ hypothesis holds true the cyclotron energies do not depend on mass of the charged particle. Also a decay to bunches of *n* of photons with ordinary energy is possible. Both mechanisms could be involved. The bunches of *n* ordinary quanta could drive electromagnetic oscillations and mechanical (acoustic) oscillations. In piezo-electrets populating living matter the transformation of electromagnetic and acoustic oscillations to each other is possible. 4. The rate Γ of DNS events is in the first approximation proportional to the number of plasma balls events if the DNS even for single ball feeds energy for the entire system. Γ cannot be much lower than $f_c(Ar^+) = .5$ Hz since the system would remain to crystal-like phase. It Γ is too high, the transition to gas phase becomes impossible.

Is the frequency $f \sim .01$ Hz needed in TGD based model?

It is not at all clear whether frequency $f \sim .01$ Hz required by the stochastic resonance model is needed nor even possible as a cyclotron frequency in TGD inspired model.

- 1. If f is present, one can wonder whether it could be associated with the cyclotron BE condensate at the magnetic bodies of plastic balls. Could the plastic balls at some level in the hierarchy of space-time sheets behave like particles in quantum sense (the space-time sheet assignable to the plastic ball)? Does it make sense to talk about crystal-like phase as a kind of cyclotron BE condensate of charged plastic balls? Or is there energy feed from quantal cyclotron degrees of freedom assignable to the magnetic flux tubes to classical degrees of freedom of plastic balls?
- 2. The simplest working hypothesis to be killed is that both plastic balls, protons, and Ar^+ ions are at the same flux tubes of MB so that the value of magnetic field is fixed to about $B_{end}/15$, $B_{end} = .2$ Gauss. The order of magnitude for the cyclotron frequency turns out to be several orders of magnitude lower than f = .01 s. Hence it seem that there is no obvious manner to introduce $f \sim .01$ Hz in the model.

The following little calculation gives the estimate.

1. One has $f_c = QB/2\pi M$, where Q = CV and C is the capacitance of the plastic ball. C is purely geometric parameter and for single ball with radius d embedded in dielectric with relative permittivity ϵ_r it is determined by the value of Coulomb potential $V_c = Q/4\pi\epsilon$ at the surface of the ball. This gives

$$C/Farad = 4\pi\epsilon d = \epsilon_r \times (d/meter) \times 5.224 \times 10^{-12}$$

2. The mass of the ball is given by $(4\pi/3)\rho d^3$, where ρ is the density of the ball which in an approximation needed for order of magnitude estimates given by

$$\rho = \frac{m_p}{a^3} , \quad \frac{a}{Angstrom} = 1$$

3. From this one obtains for the cyclotron frequency the expression

$$\begin{aligned} f_c(ball) &= 3 \times \epsilon_r \frac{d}{meter} \times (\frac{a}{d})^3 \times \frac{V}{Volt} \times \frac{B}{B_{end}} \times 3.3 \times 10^7 \times f_c(p, B_{end}) \\ f_c(p, B_{end}) &= \frac{eB_{end}}{m_e} = 300 \ Hz \end{aligned}$$

Using the values

$$rac{V}{Volt} = 6$$
 , $rac{d}{meter} = 10^{-5}$, $ho = rac{m_p}{a^3}$, $B = rac{B_{end}}{15}$

this gives the estimate

$$f_c(ball) \simeq \epsilon_r \times 5.8 \ days$$
 .

For vacuum with $\epsilon_r = 1$ the frequency is smallest possible. It is not possible to obtain $f_c \sim .01$ Hz for reasonable strength of B.

What about cyclotron frequencies of cells and cell membranes assuming $B = B_{end}$?

1. Cells are also negatively charged but the charge of the cell is rather small (see http://tinyurl.com/yb9w6nqs)- about $10^3 e$ for yeast cell so that Q/M ratio is very small.

2. What about cell membrane treated as single unit? The capacitance per unit area does not depend much on cell (see http://tinyurl.com/chylvs9) being given in good approximation by

$$c = \frac{dC}{dS} \frac{cm^2}{Farad} = 2 \times 10^{-6} \quad .$$

The capacitance is from this given by $C = c \times S$. Assuming spherical symmetry, the estimate for the cyclotron frequency $f_c(membrane)$ is

$$f_c(membrane) = 3c \times a^2 \times \frac{a}{d} \times f_c(proton, B_{end}) \times \frac{Coulomb}{e} \times \frac{V}{Volt} = 1.5 \times 10^{-7} \times \frac{10\mu m}{d} \times \frac{B}{B_{end}} \times \frac{V}{.05 \ Volt} \ Hz$$

For $d = 10 \ \mu m$ and $B = B_{end}$ and V = .05 Volt the cyclotron time is 77.2 days. For DNA sequences the cyclotron frequencies are around 1 Hz irrespective of their length.

Some observations about Argon ions

A couple of comments about the possible role of Argon are in order.

1. I ended up with the recent vision about living matter on basis of observations that the radiation at cyclotron frequencies of Ca⁺⁺ ions and also other biologically important ions have effects on physiology and behavior of vertebrates [K99, K98]. The magnetic field involved was $B_{end} = 2B_E/5$, where $B_E = .5$ Gauss is the nominal value for the magnetic field of Earth. The cyclotron frequencies of Ca⁺⁺ in B_{end} are multiples of $f_c(Ca^{++}) = 15$ Hz. Ca has (20,40) whereas Ar^+ has (A,Z) = (40,18). Therefore the cyclotron frequency of Ar^+ (which is fermion) is in good approximation one half of that for Ca⁺⁺: $f(Ar^+, B_{end}) =$ $f_c(Ca^{++})/2 = 7.5$ Hz. TGD based model for high Tc and bio-superconductivities suggests that Ar^+ ions could form Cooper pairs with members at flux tubes with opposite directions of magnetic field.

What puts the bells ringing is that $f(Ar^+, B_{end})$ is quite near to the lowest Schumann frequency assignable to the oscillations of B_E serving as a candidate for a correlate for collective levels of consciousness? Could the collective effects be partially due to B_{end} ? The problem is however that cyclotron period of Ar^+ is considerably shorter than the periods τ_V and τ_H associated with the oscillations of plasma balls and with the metabolic cycle.

2. What does one mean when one says that Ar^+ ions are dark? Could Ar^+ ions be dark atoms in the sense that the electron is not lost but is transformed to a dark valence electron with scaled up size of orbital proportional to n^2 [L72]. Ar^+ ion would be analogous to Rydberg atom [K78]. Dark electrons could form dark super-conductor coupling with its total charge to the electric field of the negatively charged electrode. The members of Cooper pairs could reside at parallel flux tubes connecting plastic balls with parallel or antiparallel magnetic fluxes. This could explain the synchronous oscillation of the plastic balls and also the formation of crystal-like phase.

Could DNS serve as the source of metabolic energy in the system studied?

The system considered requires metabolic energy. The metabolic energy would be fed to the system as it transforms to crystal-like phase and is dissipated via vertical oscillations in the force field defined by gravitational and electric fields. Unless the experimental arrangement involves a hidden energy feed, there must be present some unidentified source of metabolic energy in the system itself, that is plastic balls plus Ar^+ ion plasma.

TGD inspires the proposal that DNS generates the metabolic in pre-biotic systems, where photosynthesis need not be present yet and there is no storage of metabolic energy to biomolecules. Could something analogous to DNS take place also now?

- 1. If one wants to identify both f_V and f_H as cyclotron frequencies for the same value of magnetic field, one must assume that both Ar^+ and H^+ ions are present. Therefore the formation of dark proton sequences suffering dark weak decays to dark nuclei containing neutrons becomes possible. The TGD based model [K31] [L38, L64] predicts is that the spectroscopy of dark nuclei is the same as those of ordinary ones if dark nuclear binding energy scale and neutron proton mass difference are both scaled down like $1/h_{eff}$. The occurrence of nuclear transmutations caused by dark nucleosynthesis is the basic prediction.
- 2. Also the fusion of Ar^+ nuclei and dark nucleon sequences is possible. The dark fusion of two Ar^+ nuclei with (Z, A) = (18, 40) proceeding via formation of dark Kr nucleus consisting of two Ar^+ nuclei and transformation to ordinary Kr would produce stable Krypton isotope with (Z, A) = (36, 80) liberating nuclear binding energy ~ 7.6 MeV assuming that the dark nuclear binding energy is negligible (the model predicts it to be of order of few keV). Sn isotope with (A, Z) = (120, 50) is the lightest isotope with mass number $3 \times 40 = 120$ of 3 Argon nuclei. This would require the transformation of 4 protons to neutrons by dark beta decay to reduce total charge 54 to 50. This process would however requires energy of 21 MeV and would therefore not occur spontaneously.

Kr production would be a testable signature of this mechanism. Kr could end up to the negatively charged plastic ball or negative electrode. This would induce a loss of Argon from the system. Could the loss of Ar^+ and production of Kr ions be detectable?

DNS or at least the transformation of dark nuclei to ordinary ones could be a stochastic process. If this mechanism provides metabolic energy for prebiotic lifeforms, it should be able to sustain itself. There should be some signal making possible charge separation leading to the generation of dark proton sequences at flux tubes in turn leading to DNS and the generation of crystal-like phase in turn generating the cyclotron radiation.

1. A possible mechanism is suggested by Pollack effect [L36] [L36] occurring in water environment bounded by gel in the presence of suitable signal providing energy. There are several kinds of signals providing energy such as light at visible or IR frequencies or even a mechanical perturbation. What happens that water molecules, which are already in excited state near the splitting of hydrogen bond lose one proton as they absorb photon and proton becomes dark and goes to magnetic flux tube. The generation of the excited state requires UV energy of order 5 eV. Solar radiation or possibly occurring DNS events could provide the UV light.

In the recent case water and gel phase are missing. One might however hope that the dark photons - say those with UV energies - transforming to ordinary photons could induce charge separation in BF balls or at their surface layers and transform protons to dark protons at flux tubes. If the cyclotron radiation from decaying cyclotron BE condensates corresponds to a value of Planck constants for which dark photons transform to bio-photons, this condition is satisfied. This is implied by $h_{gr} = h_{eff}$ hypothesis. If this takes place the total negative charge of plasma balls should be larger than the total charge of Ar^+ ions.

2. Could the charge separation zg the surface of plasma balls give rise to an analog of cell membrane like structure giving rise to (generalized) Josephson junctions? If so, the analogy with living cell would become even deeper. Also the flux tubes between plasma balls act as Josephson junctions making possible oscillating non-dissipating currents generating dark Josephson photons with energy E = eV and frequency $f_J = eV/h_{eff}$.

14.3.3 Speculative connections with TGD inspired views about quantum biology and consciousness

The model for the findings has allowed to develop in more detail the basic ideas of TGD inspired quantum biology.

1. The model has led to a concrete proposal for how the MB controls BB using forced electromagnetic and mechanical oscillations at low frequencies by using the transformation of dark photons to bunches of low energy photons. Also the analogs of Alfwen waves suggest themselves as a control mechanism. 2. DNS could provide a universal pre-biotic mechanism for producing metabolic energy and the needed elements. This mechanism might be active even in the recent biology in some exceptional situations [I44]. DNS is also predicted to precede ordinary nucleosynthesis in pre-stellar evolution so that primordial metabolism would not depend on chemistry and prebiotic and pre-stellar evolution could proceed hand-in-hand and DNS would produce heavier elements also outside the stars [L64].

Even more, TGD based model for dark DNA identifies sequences of dark protons as analogs of DNA with sequence of 3 protons serving as analog of DNA codon. Also the dark analogs of RNA,tRNA, and amino-acids are predicted. Dark DNA sequences are dark nuclei so that the emergence of dark DNA would mean also the emergence of DNS as a basic metabolic mechanism. This would resolve the egg-or-hen problem about whether genes or metabolism came first.

- 3. The chemical structure of plastic balls involves aromatic 6-cycles associated also with DNA nucleotides. Both DNA and cell are negatively charged and thus analogous to the negatively charged plastic balls. Could negatively charged regions, about which the exclusion zones (EZs) of Pollack formed to water in presence of say visible light have served precedessors of cells?
- 4. Gel-sol transition and protein folding and unfolding are basic processes of cell biology. Could the proposed basic control mechanisms control also these processes. Could gel-sol transition and protein unfolding correspond to a melting of crystal-like structure and splitting of flux tube pairs to U-shaped flux loops or vice versa induced by a change of h_{eff} ?
- 5. Could quantum criticality realized as a family of flux tubes with fixe L/S ratio and same energetics but with varying value of $h_{eff}/h = n$ make possible the adaptation of the dynamics of MB to the dynamics of various oscillations of BB? This would be essentially entrainment making possible both sensory perception and motor actions. Control of mechanical processes at the level of ordinary matter would involve the decay of dark low frequency photons to nordinary photons. Chemical control would involve transition to single ordinary photon with *n*-fold frequency.

This view is also supported by the realization that brain consciousness is not a continuous stream but more like a sequence of flashes (see http://tinyurl.com/y84az3bh). This is one of the basic predictions of TGD inspired theory of consciousness based on what I call zero energy ontology (ZEO). One can say that the sub-self (mental image) is a life-cycle of a conscious entity and that one has sequences of this kind of periods with opposite arrows of time: self dies and reincarnates with opposite arrow of time. Consciousness would have sleep-awake cycles in all time scales. This would give rise to various bio-rhythms. In EEG this would show itself as a decomposition to portions of duration of order .3 seconds.

In ZEO this could be interpreted in terms of a sequence of life cycles in which time increases in opposite directions: first at (call it) "upper" boundary of causal diamond (CD), which shifts towards geometric future, then at "lower" boundary, which shifts to geometric past, and so on.... Note that the birth at given boundary is only slightly later than the latest death at it so that also our wake-up period at level to which EEG is associated could be repeated births and reincarnations forming an approximate continuum at given boundary of CD. Also wake-up-sleep cycle could be like this. Strobing character is predicted to be a universal feature of consciousness.

In TGD inspired quantum biology the strobing character of consciousness can be related to the nature of metabolism, which does not take place as continuous feed of energy but as doses with some average rate.

To sum up, the cautious non-orthodox proposal is that the description of the finding in terms of the notions of non-equilibrium thermodynamics might not be enough. Rather, a generalization of quantum theory introducing a hierarchy of Planck constants explaining dark matter and providing a general TGD inspired model for living matter would be needed.

14.4 A system of particles able to self-assemble and self-heal in presence of acoustic waves

In previous section as system consisting of plastic balls as a system exhibiting primitive like properties was dicusse. Another very simple system with life-like properties consist of particles floating on top of a glycerin-water solution.

14.4.1 Experimental discovery

A popular article "Sound waves direct particles to self-assemble, self-heal" (see http://tinyurl. com/ybefq2ah) telling about another particle system far from thermal equilibrium and exhibiting life like properties. Scientists at the Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab) demonstrated how particles, floating on top of a glycerin-water solution, synchronize in response to acoustic waves blasted from a computer speaker. The article "Emergence of an enslaved phononic bandgap in a non-equilibrium pseudo-crystal" [D6] (see http://tinyurl.com/ybugqjr6) telling about the study is published in the journal Nature Materials.

In this case there is an energy feed to the system realized as a monochromatic sound wave. The system responds to an incoming sound wave and gradually the average response of the system which is in the beginning of the experiment essentially constant as function of wavelength develops a wave length gap in the response below the wave length of the incoming sound wave. The emergence of forbidden wavelengths can be interpreted as a synchronous response modellable as a reaction of damped oscillation to a driving force at resonance frequency. The video of the popular article shows how the wave length gap emerges in time scale of 45 minutes. Also the theoretical prediction for the response is given as a curve and is agrees rather nicely with the outcome.

The comment of the co-lead author Chad Ropp, a postdoctoral researcher in Zhang's group is following.

We show that individually 'dumb' particles can self-organize far from equilibrium by dissipating energy and emerge with a collective trait that is dynamically adaptive to and reflective of their environment. In this case, the particles followed the 'beat' of a sound wave generated from a computer speaker.

To my opinion "beat" cannot however mean here what it means usually since this requires that input acoustic signal would be superposition of signals with nearly same frequencies and beat would occur with frequency which is difference of these. This unless one interprets the acoustic signal as beat signal associated with the frequency difference.

The abstract of the article gives a more technical description about what happens.

"Material systems that reside far from thermodynamic equilibrium have the potential to exhibit dynamic properties and behaviours resembling those of living organisms. Here we realize a non-equilibrium material characterized by a bandgap whose edge is enslaved to the wavelength of an external coherent drive. The structure dynamically self-assembles into an unconventional pseudocrystal geometry that equally distributes momentum across elements. The emergent bandgap is bestowed with lifelike properties, such as the ability to self-heal to perturbations and adapt to sudden changes in the drive. We derive an exact analytical solution for both the spatial organization and the bandgap features, revealing the mechanism for enslavement. This work presents a framework for conceiving lifelike non-equilibrium materials and emphasizes the potential for the dynamic imprinting of material properties through external degrees of freedom.

The system has energy feed as acoustic wave (from the left in the video) which gradually shifts the system to the right. Therefore the far from equilibrium thermodynamics without stochastic resonance works satisfactorily. TGD vision might provide a competing quantum description.

Also now the system involves materials appearing in living matter. Glycerin is closely related to glycerol and glycerol (see http://tinyurl.com/p7mr2bj) backbone appears in lipids serving as basic building bricks of cell membrane). Glycerin is dissolved in water, which is in a key role in TGD inspired quantum biology. Since I have only access to the abstract of the article, I do not know what is whether the particle are organic material too.

14.4.2 TGD inspired model

One can develop a model for the system based on TGD inspired quantum biology. This involves the notion of magnetic body carrying dark matter identified as $h_{eff} = n \times h$ phases; a network of magnetic flux tubes (magnetic body (MB)) controlling biological body and responsible for coherence and synchrony; the control of the oscillations of BB by cyclotron radiation resulting from decays of cyclotron condensates of charged particles. The source of metabolic energy would come from dark nucleosynthesis explaining nuclear transmutations occurring in living matter and "cold fusion" and serving as a source of metabolic energy in the prebiotic stage when the chemical energy storage had not yet emerged. Dark analogs of DNA, RNA, tRNA, and amino-acids are dark protons sequences realizing degeneracies of vertebrate genetic code are dark nuclei and can transform to ordinary nuclei and liberate nuclear binding energy so that the hen-egg question about which came first: metabolism or genetic code, is resolved: hen= egg.

The recent view about self-organization [L107] based on zero energy ontology (ZEO) based quantum measurement theory predicts that in "big" (ordinary) state function reductions (BSFRs) the arrow of time changes. In time reversed mode dissipation occurs in the reversed time direction and looks like energy feed (or extraction of energy from the environment). This allows "breathing" of the system as a sequence of BSFR even in the absence of energy feed.

In the recent situation the simple system is a particle system with a feed of acoustic energy at single wavelength. What happens is that the distribution of particles develops synchronous oscillations in the wave length band, and the amplitudes are reduced in this band so that the wavelength gap emerges. The system is also able to heal. The interpretation is in terms of the emergence of flux tube structure rigidifying the system to pseudo-crystal. The energy of the oscillations of the particles is transferred to MB where it gives rise to Alfwen waves with a wavelength band analogous to atomic energy bands.

Can one apply the general quantum description to explain the frequency gap?

- 1. The metabolic energy feed is now by acoustic oscillations and should induce the phase transition generating magnetic flux tube network containing dark particles having $h_{eff} = n \times h$ responsible for the synchronous oscillations.
- 2. Quantum criticality at the level of the MB could make adaptation possible. The flux tubes with same ratio of L/S of length L and transversal area S scaling like $h_{eff}/h = n$ so that L/S remains invariant under scalings of h_{eff} correspond to same magnetic energy and cyclotron energies. Adaptation would mean that cyclotron frequency for BE condensate of say protons at magnetic body becomes nearly equal to the frequency of sound wave by a suitable choice of n if the value of magnetic field strength is in reasonable range: this means that flux tubes tune their length and thickness by magnetic motor actions. Note that in pseudo-crystal phase exhibiting life-like aspects it would be MB which drives rather than sound wave. Cyclotron radiation from BE condensates at MB would drive the synchronous oscillations of particles at the nodes of flux tube network performing oscillations (generalization of Alfwen waves to oscillations of flux tube analogous to string vibrations).
- 3. The wavelength distribution of the response evolves from an asynchronous response of the particles to acoustic wave to that corresponding to pseudo-crystal and dictated by the response of MB to acoustic wave. In the initial situation the response does not depend on λ . The response of MB affects the particle system only in a narrow band of wavelengths below $\lambda = lambda < 0$ and "freezes" it in this range.
- 4. The quantum model for the plastic ball system would suggests an analog of entrainment with the acoustic frequency occurring also in brain. Flux tube network would "freeze" the acoustic oscillations of the system of balls in the wavelength gap forcing them to oscillate in phase but with reduced amplitude. The energy would go to increasing the magnetic energy of flux tubes and to Alfwen waves of MB analogous to lattice oscillations and having a wavelength band around the acoustic wavelength. Due to the "freezing" the amplitude of the oscillations becomes small in the gap. The energy distribution in the wavelength region outside the gap would not be affected.

The analogs of Alfwen waves are realized as stringy oscillations of magnetic flux tubes at MB. Alfwen waves have a wavelength band around the acoustic wavelength. The wavelength band is analogous to energy bands associated with energy levels of atoms in solids.

5. The healing of the system would mean a regeneration of the MB or the self-organization of the system controlled by under metabolic energy feed. ZEO making possible time reversals and extraction of "metabolic" energy from the environment would make possible "breathing" and healing even in absence of energy feed: in time reversed mode thermal energy would serve as energy feed. The ability to react to sudden changes in the environment might be understood in terms of the ability of MB to adapt in the proposed manner. It would be interesting to see how the system reacts to the change of the acoustic frequency. The model would require change of the value of $h_{eff}/h = n$.

To sum up, essentially the same quantum model could describe both the system of plastic balls and the recent system. Now acoustic wave would serve as the source of metabolic energy and metabolic energy would be fed to MB.

14.5 A model for the control of biological body by magnetic body

The recent work in attempts to understand various surprising findings [I79] [D6] about very simple self-organizing systems assuming that they are actually macroscopic quantum systems at the level of magnetic body (MB) leads to a rather concrete model for how MB carrying dark matter identified as $h_{eff}/h = n$ phases controls the part of system consisting of ordinary matter - biological body (BB) in biological context. The key element is magnetic body (MB) involving flux tube network able to make $h_{eff} = n \times h$ changing phase transition changing its connectivity (the extreme corresponds to phase transition between crystal-like and plasma-like states).

The control is assumed to involve Alfwen waves with the frequencies of cyclotron transitions for the dark matter. Alfwen waves induce resonant forced oscillations of the particles at the nodes of the network. MB adapts to the dynamics of BB by using quantum criticality: if the length L and transversal area S of flux tube are scaled up by n, the ratio L/S is unaffected and the energetics of the system (cyclotron energies and the magnetic energies of the flux tubes) remains un-affected but frequencies scale by n. By a suitable choice of n system and L/S ratio MB can gain control over BB.

In the sequel this picture is tested in biological context. If MB controls basic biological processes at BB then cyclotron frequencies for biologically important ions determine the time scales of basic bio-processes involving various kinds of molecular motors. In communications from BB to MB the difference Δf_c of cyclotron frequencies of ions associated with cell membrane at different sides of cell membrane and would determine the time scales of these communications [K103, K48, K98]. For large enough values of n membrane potential would add a small contribution $\Delta f = ZeV/h_{eff}$ to Δf_c and code nerve pulse patterns and therefore sensory information to the Josephson radiation.

14.5.1 The basic hypothesis

The basic hypothesis which led to the idea about hierarchy of dark matter labelled by n and having purely number theoretic interpretation in adelic physics [L74] is that the magnetic field at flux tubes has a spectrum of values. The ideas ab out the spectrum for the values of magnetic field has generalized gradually.

- 1. The first working hypothesis inspired by the work of Blackman [J29] was that the most important value is what I have called endogenous magnetic field $B_{end} = 2B_E/5$, where $B_E = 0.5$ Gauss is the nominal value of the Earth's magnetic field.
- 2. This assumption turned however to be too restrictive. The spectrum of visible bio-photons identified as resulting in a phase transition transforming dark photons to ordinary photons with the same energy would correspond to that of magnetic fields corresponding to single octave.

- 3. The hypothesis that bio-photons with energy range in visible and UV assignable to molecular transition energies result from dark photons by energy conserving transition, predicts that actually several octaves are involved.
- 4. One can assign the spectrum of magnetic fields strengths also to the audible frequencies making in the case of humans 10 octaves. One could see the emergence of higher octaves as outcome of evolution extending gradually the repertoire of control actions performed by MB.
- 5. One can argue that the field strengths at MB are probably not higher than say .2 Tesla, which corresponds to $10^4 \times B_{end}$ and to 13 octaves as an upper bound for the range of magnetic fields. This gives a strong upper bound for the cyclotron frequencies. In case of proton the upper bound is $f_c(p) < 3$ MHz. For bats the range of audible frequencies extends to MHz. In the case of Fe this would correspond to $f_c(Fe^{2+}) < .1$ MHz. This gives a strong limitation on processes controllable by cyclotron radiation.

For signals from cell membrane the limits are not so strong. Suppose that generalized Josephson frequencies are responsible for the communications. Ordinary Josephson frequency equals to ZeV/h_{eff} , where $V \sim .05$ Volts is membrane potential. For small h_{eff} ordinary Josephson frequency dominates over the difference of cyclotron frequencies this allows rather high frequencies below 5×10^{12} Hz. One might argue that at this limit BB sends metabolic energy to MB. For large values of h_{eff} ordinary Josephson frequency gives only rise to a small modulation coding for nerve pulse patterns. At this limit BB would send only information to MB.

In the following the simplest hypothesis $B = B_{end}$ is taken as a starting point and applied to various situations. One can make several questions. One can consider the situation from the point of view of control of BB by MB and communications from BB to MB.

1. Control of BB by MB.

The most important activities are control of phosphorylation of ADP to ATP using ATPase enzyme, replication and transcription of DNA, and translation. Various molecular motors such as ATPase, DNA and RNA polymerases, helicases, and various propellers (flagellas, kinesin, dynein) represent examples of bio-control.

What could one say about the role of the control based on cyclotron radiation at the level of bio-catalysis? For instance, could one understand the time scales of DNA transcription and mRNA translation. Note that they should be nearly the same in an optimal situation so that also the corresponding cyclotron frequencies should be essentially same. Could one understand the role of cofactors - say Mg^{2+} - necessary for the action of enzymes using cyclotron radiation hypothesis?

2. Communications from BB to MB.

If generalized Josephson radiation from the cell membrane to MB is responsible for these communications then the cyclotron frequencies for the ions assignable with nerve pulse transmission should be of key importance.

14.5.2 Metallic and organic cofactors

Cofactors (see http://tinyurl.com/d6jnd49) are necessary for the functioning of enzymes possibly realizing the bio-control by MB. They can be divided into metal ions and organic co-factors. The working hypothesis is that the cyclotron frequencies associated with co-factors coordinate the functioning of enzyme and determine the ratew of the processes involved.

It is assumed that for given oxidation state assignable to a compound also free ion with ionization state equal to the oxidation state can appear. Table 14.1 gives the cyclotron frequencies of metallic cofactors for their oxidation states.

For instance, the ions Mg^{2+} , Mn^+ , Cu^+ , appear as metallic cofactors. For $B = B_{end}$ they have cyclotron frequencies 25.0 Hz, 10.9 Hz, and 4.8 Hz ($f_c(Fe^{2+}) = 2f_c(Mn^+)$). Note that Ca^{++} is often regarded as signalling ion rather than co-factor but that it has also important role in catalysis. A natural guess is that the cyclotron frequencies define typical rates for bio-catalytic reactions for which enzyme has metal ion as a co-factor.

Metal	A	Oxidation states	f_c/Hz
Mg	24	2	25.0
Ca	40	2	15.0
Cr	52	3	17.3
Mn	55	2	10.9
Fe	56	(2,3)	(10.7, 16.0)
Co	59	(1,3)	(5.1, 15.3)
Cu	64	1	4.7
Zn	65	2	9.2
V	51	2,, 5	(9.2,, 29.4)
Mo	96	-2, 1,, 6	(3.1,, 15.7)
Cd	112	(1,2)	(2.7, 5.4)
Ι	127	(1, 2,)	(2.4,)

Table 14.1: Metallic cofactors possibly important for the control of BB by MB. A denotes atomic weight for the most stable isotope. Cyclotron frequencies are calculated for $B_{end} = .2$ Gauss.

Ion	A	Oxidation states	f_c/Hz
$\parallel Li^+$	(6,7)	1	(50.0, 42.8)
Na ⁺	23	1	13.0
Cl^-	55	-1	8.6
K^+	39	1	7.7
Ca^{++}	40	(1)	15.0

Table 14.2: Ions possibly important for communications from BB to MB. A denotes atomic weight for the most stable isotope. The smallest cyclotron is calculated for $B_{end} = .2$ Gauss.

There also organic cofactors having typically mass number less than 1000. This implies that cyclotron frequency is above $f_{min}0.3 \times Z$ Hz for $B = B_{end}$ if the organic cofactor has charge Z. The first guess is that also their cyclotron frequencies are important and play the same role as those of metallic cofactors. These cyclotron frequencies are considerably lower than metallic cyclotron frequencies unless the cofactor has constant charge density. DNA is a good example of molecule with constant negative charge density: the cyclotron frequencies are rather near to 1 Hz independent of the DNA sequence.

14.5.3 Biologically important ions assignable to the communications from BB to MB

There are also other important biological ions involved with the communications from BB to MB. Besides Ca^{2+} ion also Na^+ , Cl^- , K^+ are important ions in the dynamics of nerve pulse transmission. In TGD inspired for nerve pulse and EEG the generalize Josephson frequencies for these ions are involved with the communications from brain to MB. Li^+ ion is also known to be important and too low concentration of Li^+ is known to correlate with depression and infection like state of brain.

All these frequencies are in EEG range. Li_6^+ cyclotron frequency is 50 Hz and is known to correspond to a frequency having effects on living matter. Li_7^+ cyclotron frequency is 37.5 Hz and is rather near the thalamocortical resonance frequency with nominal value of 40 Hz.

There are bio-molecules involved with signalling inside bio-system rather than from BB to MB. First messengers consist of hormones and neurotransmitters. Second messengers couple to first messengers to overcome the cell membrane barrier (see http://tinyurl.com/yajhj9zb. An interesting question is how they relate to the communications from MB to BB: could cyclotron radiation control these communications?

I have proposed that messengers do note represent real communications but only represent

the ends of the communication lines so that their transfer would generate flux tube connections between the sender and receiver. The real signal would proceed as dark photons and/or super currents along the flux tube connections. If so then MB would control communication by first and second messengers by building the communication lines unless they already exist as flux tubes.

Second messengers include also neutral gases such as NO, CO and H₂S. Hydrophobic molecules such as diacylglycerol, and phosphatidylinositols and hydrophilic molecules such as cAMP, cGMP, IP3 appear as second messengers. For instance, could control of MB be involved to the transformation of first messenger signal to second messenger signal. Note that also Ca^{2+} is second messenger.

14.5.4 About the role of cyclotron frequencies in the bio-control by MB

Bio-catalysis is a basic tool of bio-control and should be controlled by MB. Enzymes should involve a part making possible the control by MB, and so called cofactors (see http://tinyurl.com/d6jnd49) are excellent candidates for this part since without them enzyme does not perform its function.

In the following the cyclotron frequency hypothesis is tested for some biologically important processes assuming $B = B_{end}$. There is a web page (see http://tinyurl.com/y7aes93x) about various scales involved with the key biological processes.

I proceed from fast to slow time scales starting from ATP synthesis and proceeding via DNA related processes involving Mg^{2+} as cofactor to oxidative metabolism involving Fe^{2+} .

14.5.5 Molecular motors

Molecular machines (see http://tinyurl.com/h3dqauo) are divided into two categories: molecular switches, which perform control actions and molecular motors. One might regard molecular switches as higher level motors. Here is a brief summary of molecular motors.

Molecular motors (see http://tinyurl.com/y879vdel) come in several types.

1. Rotary molecular motors include F_0F_1 ATP synthase (briefly ATPase) family of proteins (see http://tinyurl.com/h23hjkn) converting the electrochemical energy in presence of a proton gradient over the cell membrane to the chemical energy of ATP (or vice versa).

The rotary motion of the shaft of F_0F_1 rotor makes the addition of phosphates. The rotating shaft is analogous to an assembly line containing ADPs to which phosphates are added as it rotates. The flow of protons through cell membrane pumped back through membrane using the metabolic energy from nutrients provides energy for the rotary motion and ATP. One can wonder whether this energy is provided as dark Josephson photons.

The maximal rotation frequency is 300 Hz which corresponds to the proton cyclotron frequency for $B = B_{end}$. This suggests that dark protons at either side of membrane structure could coordinate ATP synthesis. ATP serves as universal metabolic energy currency so that this mechanism would appear everywhere in bio-logy.

The rotary motor controlling flagellum can turn as fast as 300 Hz (see http://tinyurl.com/yaoowf91 and http://tinyurl.com/ybotnsg4), which suggests that proton cyclotron frequency in B_{end} determines the upper limit for the rate.

2. Polymerization motors are rather complex motors. Actin polymerization uses ATP. Microtubule polymizerization GTP uses GTP. Dynamine (see http://tinyurl.com/ycp5t52p is a GTPase responsible for the separation of clathrin buds from the plasma membrane.

Actin (see http://tinyurl.com/y9npk83f) polymerization involves competing factors (see http://tinyurl.com/y7hqmm72). The rate has upper bound .3 $\mu m/s$. Actin monomer is called G-actin, and actin (micro-)filament formed from actin monomers is called F-actin. Actin monomer has mass of 41,795 proton masses and charge of -7 units (for B_{end} this would correspond to cyclotron frequency .05 Hz).

Actin monomers are accompanied by both ATP molecule and Mg^{2+} suggesting that both cyclotron frequencies are involved with the coordination of polymerization. From the length taken by single actin monomer about 2.75 nm one can conclude that the average rate is in the range 5.5 actin monomers per second to be compared with the $f_c(Mg^{2+}) = 25$ Hz. The assumption that cyclotron frequency coordinates the process does not seem plausible.

3. Cytoskeletal motors (myosins for muscle contraction, kinesin for moving cargo along microtubules, and dynein producing axonemal beating of flagellum and moving cargo along microtubules). These rely on ATP so ATPase (dark proton cyclotron frequency) is expected to dictate the rate. These motors bind filamentous actin and are also rather complex.

Nuclei acid motors

There is a large variety of nucleic acid motors. Consider first motors, which do not utilize ATP.

1. DNA polymerase (see http://tinyurl.com/y9k9k8zj) turns single-stranded DNA to doublestranded DNA. These motors use deoxynucleoside triphosphate XTP, C= A, T, C, G. XTP transforms to XMP by dropping diphosphate and XMP is attached to the growing DNA strand. Note that ATP gives only P to the acceptor molecule.

One can distinguish between two rates.

- (a) The average DNA polymerase requires about one second to locate and bind to a primer/template junction. Once it is bound, a non-processive DNA polymerase adds nucleotides at a rate of one nucleotide per second. Interestingly, the cyclotron frequency of DNA sequence in B_{end} is near 1 Hz irrespective of the length.
- (b) Processive DNA polymerases works much faster since single catalytic event adds large number of nucleotides to the polymer. The rate of processive polymerization at 37 °C is 749 nucleotides per second and corresponds to about 250 codons per second. This suggests that the rate of processive polymerization is determined by ATPase driven at proton cyclotron frequency of 300 Hz.
- 2. RNA polymerase (see http://tinyurl.com/y982vb46) catalyzes the transcription of DNA to RNA (see http://tinyurl.com/ydaosrhg). The basic mechanism might be though to be similar to that of DNA polymerase but the structure of these molecules is different. RNA polymerization is also 20 times slower that than DNA polymerization in E. Coli suggesting that cyclotron frequency of Mg⁺⁺ ions, which are indeed involved, determines the rate.

The averate rate for DNA transcription and RNA translation has upper limit of 24 codons per second and could naturally correspond to the cyclotron frequency 25 Hz of Mg^{2+} for $B = B_{end}$ appearing as cofactor in the catalyst.

3. DNA helicases (see http://tinyurl.com/y8h3jsq2) separate double strands of nucleic acids prior to transcription or replication. DNA replication, transcription, translation, recombination, DNA repair, and ribosome bio-genesis utilize DNA helicase. DNA strand is known to rotate during the transcription.

If the rotation is in a direction opposite to the twisting of DNA strand, the DNA strand could open if helicase simply fixes the position part of DNA codon at which the transcription begins. Since the strands are twisted in opposite directions, this mechanism requires that the transcription takes in opposite directions for the complementary strands: this is indeed known to be the case. The average rate of opening is about 20 codons per second and opening of the strand. The rate of opening could thus be determined by the RNA polymerase having Mg^{++} as cofactor.

Using quantum classical correspondence (QCI) the classical angular momentum assignable to the rotation of DNA can be estimated to be

$$\frac{L}{\hbar}\sim 2\pi N \langle A \rangle \frac{d^2 \times f}{L_p} \sim 172 \times N ~~. \label{eq:Lagrangian}$$

Here N is the number of rotating nucleotides, $\langle A \rangle \sim 300$ is the average weight of DNA nucleotide, $d \sim 1$ nm is the radius of the helix, $L_p = m_p/\hbar$ is proton Compton length, and $f \sim 20$ Hz is the estimate for the rotation frequency.

- (a) If $h_{eff}/h = n$ serves as a unit of quantized angular momentum (thish need not be the case for ordinary DNA as opposed to the dark analog of DNA for which the states 3 dark protons define a realization of DNA codons) an upper bound $n < n_{max} \sim 172 \times N$ emerges from the condition $L/\hbar_{eff} = 1$. The interpretation of dark DNA as dark nuclei gives the estimate $h_{eff}/h = d/L_p \sim 2^{20} \simeq 10^6$ the radius of nucleus. This would require $N \sim 10^4$.
- (b) Another manner to satisfy the stronger quantization condition is to assume that the semiclassical quantization condition is satisfied for the system consisting of *both* ordinary and dark DNA. The simplest manner to satisfy the condition is that the angular momenta of ordinary and dark DNA are opposite and in this case be smaller than \hbar_{eff} . This condition would be rather natural since there would be no need to bring angular momentum to the system from outside by applying torque. Energy is however needed to break up the hydrogen bonds between strands.

There are also nucleic acid motors utilizing ATP and deserve to be listed.

- 1. Topoisomerase reduces supercoiling of DNA in the cell.
- 2. RSC and SWI/SNF complexes remodel chromatin in eukaryotic cells.
- 3. SMC proteins are responsible for chromosome condensation in eukaryotic cells.
- 4. Viral DNA packing motors inject viral genomic DNA into capsids.

Also ribosome (see http://tinyurl.com/yacy6m3h and http://tinyurl.com/ybfqa423) is a molecular motor. For some reason the list of Wikipedia article (see http://tinyurl.com/ y879vdel) does not include it. The rate of translation is in good approximation the same as the rate of transcription as it indeed must be to make the process effective and Mg^{2+} cyclotron frequency might determine the rate.

For all motors involving ATP cyclotron frequency of proton is involved but and poses only upper limit for the rate.

The possible role of Mg^{2+} in RNA translation

Transcription and translation both occur on the time scale of 1 minute for a protein of typical length (see http://tinyurl.com/ycm5uur9). However, longer transcripts and bigger proteins take proportionally longer to make: this probably due to the additional operations involved. The largest protein in the human body is titin. It would take approximately an hour to translate its $\sim 30,000$ amino acids, which makes 8 amino-acids per second. If DNA codons are transcribed with the same average rate than amino-acids are translated (synchrony), transcription rate is 24 nucleotides per second. This happens to be rather near to $f_c(Mg^{2+}) = 25Hz$ to letter.

The estimates for the translation rate however vary. Probably this is due to the definition used and the organism in question. For E. Choli the average translation rate is reported to be roughly 20 aa per second (see http://tinyurl.com/ycm5uur9). For synchrony this would correspond to 60 nt/s in DNA transcription. The actual transcription rate is 40-80 nt/s for nucleotide and gives 60 nt/s on the average.

Note that the range for the rate corresponds to octave. If cyclotron radiation coordinates the process, the variation could be due to variation of magnetic field strength by octave. For DNA codon the rate would be in range [13.35-26.7] codons per second. This could correspond to Mg^{2+} cyclotron frequency in B_{end} assignable to co-enzyme Mg^{2+} (see http://tinyurl.com/d6jnd49).

Translational motion and propeller mechanism

Molecular propellers (see http://tinyurl.com/y7ftgzuk) can be rotated by molecular motors that can be driven by chemical, biological, optical and electrical means or various ratchet-like mechanisms. Biological propellers are therefore only a special case. In the case of biological propellers interaction with the medium and dissipation are involved and transform rotational motion to linear motion. Medium or substrate structure such as medium or microtubule receives the recoil angular momentum.

Biology involves a large number of highly sophisticated molecular motors, such as myosin, kinesin, and ATP synthase based on propeller mechanism. For example, rotary molecular motors attached to protein-based tails called flagella can propel bacteria (see http://tinyurl.com/ y83939x7). In this case the rotation frequency has 300 Hz, which suggests that ATPase and dark protons in magnetic field B_{end} with it determines the rate.

Second example is kinesin moving linearly along microtubule (see http://tinyurl.com/ o4glesu). Also kinesin can be regarded as ATPase. The linear motion supports several functions such as mitosis, meiosis and transport of molecules along axon. The linear motion takes place in discrete steps of length 8 nm (cell membrane thickness is about 10 nm).

One can raise several questions related to the possible role of MB. How the energy and angular momentum are transmitted to the propeller? Could dark cyclotron BE condensates analogous to magnets be formed? For cyclotron BE condensates spin would be replaced with orbital angular momentum for the dark ions rotating at flux wall: this could give rise to large angular momentum. Could the generation of cyclotron BE condensate and angular momentum at magnetic flux wall give rise to opposite angular momenta at the propeller as a recoil effect: could this quantum phase transition happen by the exchange of polarized cyclotron photons. Does ATP provide the metabolic energy needed to build the cyclotron BE condensate in turn giving part of its energy for the propeller.

14.5.6 Oxidative metabolism, red cells, the fundamental bio-rhythm, and iron

Understanding the possible role of cyclotron radiation in the coordination and control of cellular respiration (see http://tinyurl.com/pkfup3g) is a further natural challenge.

- 1. The basic guidelines are the interpretation of "high energy" bonds as containing dark electrons $h_{eff}/h = n$ larger than for normal atoms. Also dark protons must be present when the molecule containing dark electrons is neutral. Metabolism could be basically transfer of dark protons and electrons from the nutrients possibly reducing gradually the value of n and gradually sharing the liberated energy. The energy would go to the pumping of protons through the cell membrane and be eventually transferred to high energy phosphate bond in ADP \rightarrow ATP process in ATPase as protons flow back through the membrane.
- 2. In oxidative metabolism O_2 is used as oxidizing agent. O_2 molecules are transferred from respiratory organs to the rest of the body using hemoglobin (see http://tinyurl.com/ya5kyv6u) as a carrer. Oxygens atoms are bound to the heme part of the hemoglobin containing Fe^{2+} ion. O_2 binds to Fe^{2+} and oxidizes it so that one temporarily obtains Fe^{3+} ion and O_2^- (superoxide) ions.

Concerning cyclotron frequencies, what puts bells ringing is that both $f_c(Fe^2) = 10.7$ Hz, $f_c(O_2^-) = 9.7$ Hz are in alpha band and near to the fundamental biorhythm with frequency 10 Hz: could the fundamental biorhythm be seen as a direct signature of the role of MB in metabolism? $f_c(Fe^{3+}) = 16.0$ Hz is in beta band. $f_c(Fe^{3+}O_2^-) = 6.8$ Hz makes sense at least formally and is in theta band. One can of course ask whether it is possible to regard Fe^{3+} ion and O_2^- ions as independent, possibly dark, cyclotron states. If the electrons involved are dark this might make sense.

3. In an-aerobic respiration (see http://tinyurl.com/m955wzb) sulfate (SO₄², $f_c = 6.3$ Hz), nitrate (NO₃, $f_c = 6.3$ Hz), sulphur (S, $f_c = 9.4$ Hz), or fumarate (HO₂CCH=CHCO₂H) are used instead of oxygen. Interestingly, the cyclotron frequencies for sulfate and nitrate are very near to each other and for sulphur ion the cyclotron frequency is also in alpha band.

Cellular respiration converts biochemical energy from nutrients - carbohydrates, aminoacids, fats - into energy carried by ATP and then releases the waste products such as CO_2 and H_2O . The reactions include catabolic reactions breaking down the large molecules to smaller ones, releasing energy in the process as weak "high-energy" bonds are replaced by stronger bonds in the products. Cellular respiration can be seen as a combustion reaction - burning of nutrients.
The most common oxidizing agent (electron acceptor) is molecular hydrogen O₂: in this case one talks about oxidative metabolism or aerobic respiration. The energy of ATP in "high-energy" phosphate bond drives biosynthesis, locomotion or transportation of molecules across cell membranes.

Aerobic respiration is the preferred method of pyruvate (CH₃COCOO, see http://tinyurl. com/yadb3fsn) breakdown in glycolysis. Pyruvate contains two O= bonds reduced to O- type bonds in the process producing CO₂ and water. Pyruvate enters to mitochondria and is fully oxidized by the Krebs cycle (see http://tinyurl.com/p6599hq) also known as tricarboxylic cycle or citric acid cycle.

- 1. Krebs cycle produces NADH (nicotin-amide-adenine-dinuclotide containing two adenines and two phosphates, see http://tinyurl.com/mcodgjs)) carrying metabolic energy in "high energy" bonds.
 - (a) Coenzyme CoA (see http://tinyurl.com/ydbvd5q4) in acetyl-CoA (see http://tinyurl.com/z6fc4zc) brings the acetyl group CH₃ (see http://tinyurl.com/y74cyyqk) and metabolic energy from the nutrient to the Krebs cycle.
 - (b) The metabolic energy from the nutrients is associated with high energy thioester bond at the ened of acetyl-CoA in which C has bonds of type CH₃- and O= and S-. Sulphur belongs to coenzyme CoA involving phospho-adenosine and di-phosphate.
- 2. The NADH produced by Krebs cycle carrying the metabolic energy is received by the electron transport chain (see http://tinyurl.com/hxwb6ay) performing oxidative phosphorylation (see http://tinyurl.com/yacue4an) transforming ADP to ATP. NADH is oxidized to NAD⁺ and is returned back to the Krebs cycle.

Electron transport chain is needed to transfer the electrons from donors to acceptors and to extract the energy of electrons and use it to the pump of protons trough the inner membrane. Electron transport chain involves as the first step the process NADH \rightarrow NAD⁺+ H⁺ +2e⁻ producing protons and electrons. This happens inside the inner membrane of mitochondria. Electrons and protons are then transported through the inner membrane to the inter-membrane space using co-enzyme Q(10) (see http://tinyurl.com/y9tosfzc) as a carrier. Electrons are transported further with the help of cytochrome c (see http: //tinyurl.com/ybkb7dbu), which is soluble to water.

- (a) Ubiquinone enzyme Q takes care of the transfer of protons and electrons through the inner membrane to the inter-membrane space. Q receives two protons and electrons and is reduced to QH₂ at the inner side of the membrane. QH₂ oxidizes back to Q at the outer side of the membrane and therefore shuttles the protons through the membrane.
- (b) In the inter-membrane space of mitochondria (having double membrane) electrons are transferred along a chain of water cytochrome c (see http://tinyurl.com/ybkb7dbu) molecules forming a kind of ladder along which electrons move down. At given step Fe receives the electron and then gives it to the next cytochrome c molecule. At the bottom of the chain electrons with lowered energy are given to oxygen molecules in oxidative phosphorylation of ADP by ATPase.
- 3. Free radicals having one or more unpaired valence electrons appear as side products of the process. The working hypothesis is that paired valence electrons have non-standard value of $h_{eff}/h = n$ and unpaired ones have the standard value being highly reactive. Peroxides, superoxide (O_2^+) , hydroxyl radical OH, and singlet oxygen (O) are free radicals having negative biological effects. O₂ molecule is di-radical but in its ground state has parallel unpaired spins and is stable: in combustion it transforms to unstable and highly reactive spin single state with paired spins.

14.5.7 Model for RNA life

There is to a very interesting paper about the possible mechanism giving life-like properties to RNA system during the conjectured RNA era [I37] (see http://tinyurl.com/ydhr3qnq). The

title of the article is "The life story of hydrogen peroxide II: a periodic pH and thermochemical drive for the RNA world". "Life-like" would mean "breathing" realized as these oscillations and would require a metabolic energy source.

I try to interpret the proposal on basis of my own model [L71] bringing in the control of chemistry by magnetic body (MB). The idea is that MB adapts to the chemical dynamics and gets a control over it by driving forces realized in terms of dark cyclotron radiation form MB resonating with the chemical oscillations. "Breathing" would basically correspond to the periodic formation of flux tube network with high connectivity giving rise to crystal-like or gel-like state and subsequent decay to plasma-like state with low connectivity and would require metabolic energy feed.

- 1. The periodic drive is central in TGD based model and gives rise to the "breathing". Metabolic energy feed must be involved. In the model for life-like properties of plastic ball system it would be dark nucleosynthesis. In another experimental system acoustic wave feeds energy to the magnetic body (MB). It is said that the peroxide (H - O - O - H) bond between oxygens would be the source of the metabolic energy. Peroxide - usually regarded as a mere nuisance (highly Reactive Oxygen Species causing biological damage) - would serve as the "food" of the system. This is the new and radical idea. According to the article, the primary energy source would be solar or geothermal. In TGD one can consider dark nucleosynthesis preceding ordinary nucleosynthesis as the source (it might have even given rise to Fe in the core of Earth!).
- 2. Figure 1 in the article illustrates that peroxide H_2O_2 would produce in presence of $S_2O_3^{-2}$ or $S_2O_3^{-1}$ thermal and pH oscillations: "breathing". Peroxide is also told to produce oxidized sulfur species and oxidixe RNA nucleotides: this would liberate metabolic energy in RNA? The outcome would be the replication of RNA. Oxidation of thiosulfate ion by H_2O_2 mentioned in the abstract would naïvely mean that $S_2O_3^{-2}$ gives 1 or 2 electrons to H_2O_2 . Table 1 listing various reactions involved in oxidation is however rather complex. It begin to accept that I will never really understand what chemists mean with oxidation! In any case, also the oxidation reaction can happen in several steps.

Consider next the situation from quantum TGD point of view.

- 1. Periodic oxidation would correspond to breathing generating repeatedly connected magnetic body with quantum coherence and larger h_{eff} following the model for breathing plastic ball system as periodic formation of crystal-like and plasma-like states.
- 2. Cyclotron radiation from cyclotron condensates of some important ions would serve as clocks - breathing in several time scales. What are these ions? In plastic ball system protons and Argon ions. 300 Hz is the frequency for $B = B_{end} = .2$ Gauss and also the rate of ATP:s produced by ATPase: of course, it was not present at that time. This sulfate cyclotron frequency would be 5.4 Hz in B_{end} for charge of -2 units.

The chemical oscillation periods emerging in the model of authors are measured in fraction of hour whereas the cyclotron periods for ions are fractions of second for ions for $B = B_{end}$. Therefore the strength of the magnetic field is much lower than that of Earth. Intergalactic magnetic fields are of order nanoTesla and this would bring scale factor of about 10^4 to cyclotron periods and they would be of same order of magnitude as the time scales coming from chemical kinetics. For proton the cyclotron period would be 33 seconds. For $S_2O_3^{-2}$ cyclotron time scale would be scaled up by the atomic weight 112 giving roughly 40 minutes. This suggests that RNA era occurred in intergalactic space if it occurred at all. If it continues in recent biology, the dark matter must reside at the flux tubes of intergalactic magnetic field. This does not make sense in Maxwell's theory but makes sense in the many-sheeted space-time of TGD Universe.

3. pH oscillation means that at least dark protons would be involved. pH could be quite generally a direct measure for the density of dark protons. The density of dark protons oscillating periodically meaning formation of cyclotron condensate and its decay could correspond to oscillating pH.

14.6 Do hydrogels learn in presence of irradiation and heating?

A research group in Aalto yliopisto led by professor Olli Ikkala has published in Nature Communications an interesting article with title "*Programmable responsive hydrogels inspired by classical* conditioning algorithm" [I136] (see http://tinyurl.com/y6owxv8x).

The abstract of article gives some idea about what is involved.

Living systems have inspired research on non-biological dynamic materials and systems chemistry to mimic specific complex biological functions. Upon pursuing ever more complex lifeinspired non-biological systems, mimicking even the most elementary aspects of learning is a grand challenge. We demonstrate a programmable hydrogel-based model system, whose behaviour is inspired by associative learning, i.e., conditioning, which is among the simplest forms of learning. Algorithmically, associative learning minimally requires responsivity to two different stimuli and a memory element. Herein, nanoparticles form the memory element, where a photoacid-driven pH-change leads to their chain-like assembly with a modified spectral behaviour. On associating selected light irradiation with heating, the gel starts to melt upon the irradiation, originally a neutral stimulus. A logic diagram describes such an evolution of the material response. Coupled chemical reactions drive the system out-of-equilibrium, allowing forgetting and memory recovery. The findings encourage to search non-biological materials towards associative and dynamic properties.

The basic elements of the experiment are following.

- 1. The system consists of sea weed gel and Gold nanoparticles.
- 2. Heating plus irradiation by blue and red light simultaneously leads to a formation of nanoparticle chains and heating of gel melting it. Formation of chains is due to the photoacid driven pH change.
- 3. Conditioning occurs in the sense that gel melts even when only irradiation is present.

There is an analogy with Pavlov's dogs based on correspondences heating \leftrightarrow metabolic energy feed \leftrightarrow food; irradiation \leftrightarrow signal associated with the food - say sound of bell; melting \leftrightarrow saliva secretion.

One can however criticize this interpretation.

- 1. The analogy with Pavlov's dog is not complete. Melting requires energy. Pavlov's dog does not get sated by the mere soud of bell.
- 2. Nanoparticle chain is assumed to serve as a memory element. Could a more appropriate interpretation be as a metabolic energy storage analogous to protein?
- 3. Can one model the system using only chemistry, and is conditioning a purely mechanical and passive process as behavioristic dogma states? Could conscious intelligence be involved as in the case of ordinary learning.

14.6.1 TGD based model for the findings

I have already earlier applied TGD inspired model of living systes model simple systems exhibiting life-like properties. One such system consists of plastic balls [I79] (see http://tinyurl.com/z532ryv): the TGD inspired model for the system is discussed in [L71].

The TGD based quantum model for the conditioning of hydrogel system relies on TGD inspired general model of living systems extended recently to a model of quantum self-organization [L107] in which energy feed serving as metabolic energy feed induces generation of dark matter as $h_{eff} = nh_0$ phases of ordinary matter at the magnetic body of the system. In number theoretic vision the presence of these phases correspond to higher algebraic complexity and higher "IQ".

The light signal would generate Pollack effect [L36], which in TGD framework means transfer of protons from photo-acids to dark $h_{eff} = nh_0$ protons at magnetic flux tubes parallel to nanoparticle chains [L36]. The "IQ" of the system or its magnetic body characterized by h_{eff} would increase and it would become able to self-organize. The energy from the heating would be stored to the nanoparticle chains taking the role of proteins as energy storage. Melting would be a self-organization process increasing complexity, and in absence of heating (and perhaps even in its presence) the gel phase would receive the energy needed from the nanoparticle chains. The conditioning in this sense would not be a passive mechanical response. The system would be macroscopic quantum system, and the energy feed would make possible for it to evolve to a higher level of complexity and conscious intelligence.

What learning and conditioning really are in TGD Universe?

Conditioning in the standard sense would be a purely mechanical process. In TGD Universe life cannot be however reduced to mechanical purely deterministic processes.

- 1. The magnetic body (MB) of the system would not learn to get heated or to get melted in presence of the irradiation. Rather, irradiation would raise the intelligence of system measured by $h_{eff} = nh_0$ and it would spontaneously self-organize by melting. Conditioning in mechanical sense would not be in question. This would apply also to ordinary conditioning.
- 2. Conditioning in TGD sense requires conscious intelligence. MB with dark matter must be involved. The MB of the system containing the MB associated with nano-particle chains and loaded with dark protons by irradiation inducing Pollack effect would be involved with the conditioning. Irradiation would "wake up" the system and nanoparticle chains would allow energy storage.
- 3. Irradiation would generate dark phases with $h_{eff} = nh_0$ inducing self-organization involving the melting of the gel phase using the metabolic energy resources generated during the heating period. The only thing needed would be the presence of large h_{eff} phases. System would take care of the rest.

The building bricks of the model

The basic building bricks of the model would be following.

- 1. Living systems are able to learn and get conditioned. An analog of living system should be present. In TGD Universe any self-organizing system is "living" and involves dark matter as large h_{eff} phases.
- 2. Pollack effect [L36] [L36] is a fundamental manner to build MB in TGD Universe. In Pollack effect the irradiation kicks ordinary protons to magnetic flux tubes to form dark proton sequences dark nuclei. The proposal is that also a dark realization of genetic code with codons represented as 3-codon triplets is involved and that ordinary genetic code would be mimicry of this code [L44]. Also now gel and irradiation are present. Pollack effect induced by the metabolic energy feed associated with the radiation would generates dark proton phase and make the system intelligent.
- 3. Living system needs metabolic energy and must be able to store metabolic energy. Now the nanoparticle sequences possibly associated with dark flux tubes are excellent candidates for the analogs of proteins storing metabolic energy provided during the heating period.
- 4. Zero energy ontology (ZEO) plays a key role in TGD inspired model of living matter. The general model for the motor action and remote metabolism assumes that system sends negative energy to the geometric past and gets energy in this manner. Negative energy transfer is an intuitive manner to say that macroscopic state function reductions are involved in the process and change the arrow of time temporarily [L77]. Recent rather surprising experimental findings by Minev *et al* [L98] provide direct support for ZEO based view about quantum jump [L98].

Remark: Quite recently (towards end of 2019) I found a more precice formulation for the intuitive notion of remote metabolism, which strongly suggests that energy is conserved in ZEO. There is a decomposition to system and the energy energy source: call them A and B. Intuitively, A receives energy from B by sending negative energy to B. What does this really mean?

- 1. A "big" state function reduction reversing arrow of time takes place: this would correspond to sending negative energy signal to past. The energy of A+B in the final time reversed state at new passive boundary of CD would be shared in new manner such that one can say that A has received from B the metabolic energy.
- 2. Energy would be conserved. I have also considered the interpretation that the total energy of the system associated with CD increases [K85] [L114]: since CD itself breaks Poincare invariance, it seems that one cannot exclude this. However, the Poincare invariance is realized at the level of moduli space for the positions of the either boundary of CD, and one can assume energy conservation. Even the wave functions at the boundary of CD can be taken to be in the representations of Lorentz group acting as its isometries. Plane waves correspond to wave functions in the moduli space for the boundary of CD keeping second boundary fixed.
- 3. To make this more precise one must define metabolic energy more precisely by introducing the hierarchy of Planck constants and the fact that the increase of h_{eff} of sub-system keeping other parameters constant increases it energy. Second law means that A tends to loose energy due to the decrease of h_{eff} for its sub-systems. This is true also for the time-reversed state but in opposite direction of geometric time so that with respect to standard direction of time the energy increases. This would be the general purely thermodynamical mechanism of remote metabolism.

How conditioning could take place?

What kind of model this picture one ends up from the elements identified above? It is best to proceed by making questions.

- 1. What does it mean to be living in this particular case?
 - (a) Gel, nanoparticles chains, and their MB would form the system. Chain would be accompanied by flux tubes in contact with the MB of gel. MB would induce the melting in presence of irradiation.
 - (b) Pollack effect is involved. pH is changed, which means that the density of protons is changed by the presence of photoacids. photoacids (see http://tinyurl.com/y54h8dqs) release protons in presence of irradiation. The liberated protons would go to magnetic flux tubes accompanying the nanoparticle chains and even give rise to dark realization of genetic code. The photons of irradiation at blue and red should have energies needed to transfer the protons of photoacids to dark protons at the flux tubes with non-standard value of h_{eff} . Irradiation would make the system intelligent.
 - (c) photoacids are present also after conditioning so that flux tubes carrying dark protons are formed when the system is irradiated even if they are unstable against decay to ordinary protons. One can say that the system wakes up by radiation and it becomes intelligent, self-organizing, and able to learn. MB could induce melting of the gel as a self-organization process.
 - (d) Why Gold nanoparticles would be needed? Here an interesting connection to the work of Hudson and other layman researchers emerges. Hudson and others [H4, H16] claimed that Gold has a phase, which they called White Gold, mon-atomic Gold, or ORMES. This phase of Gold was claimed to have properties suggestive of nanoscopic or even macroscopic quantum coherence. These claims were not taken seriously by science professionals. Since I had nothing to lose at that time anymore, I decided to construct a model for White Gold. Later this model led to a quantum view about living matter relying on the hierarchy of Planck constants [K49, K101, ?]. The recent view about White Gold explaining their suspected quantum coherence would be as Gold nanoparticles assignable to dark magnetic flux tubes carrying dark protons.
- 2. What the melting of gel is?

Learned reaction to stimulus is in TGD framework self-organization process rather than just getting heated or reacting mechanically like automaton. What is called melting would be a

self-organization process in which the complexity of gel increases. Heat would transform to ordered energy: work would be done to achieve melting. Hence one should apply TGD based quantum view of self-organization to the situation [L107].

3. What is the source of the energy that the gel needs to melt?

Does get the energy directly as heat and/or from analogs of proteins storing metabolic energy. Since the melting occurs also in the absence of heating, the latter options seems to be correct. One can imagine two sources of the metabolic energy.

- (a) Could nanoparticle chains serve as a storage of metabolic energy being thus analogous to proteins. Nanoparticle chains dropping to a lower energy state would serve as a source of metabolic energy in absence of heating.
- (b) Could flux tubes carrying dark protons proposed to define dark variants of basic biomolecules (DNA, RNA, amino-acids, tRNA) [L44, L80, L79] serve as a storage of metabolic energy? This energy could be liberated as dark protons transform to ordinary ones. If they are transformed to protons of photoacids, the energies would correspond to the energies of blue and red photons. These energy levels should correspond to the energies assignable to the building bricks of the gel phase. The intuitive expectation is that the energy feed due to irradiation is small as compared to that needed by the melting of the gel. The presence of Gold nanoparticles would not be necessary.
- 4. What does the energy transfer from nanoparticle chain to the gel mean? One can imagine two options.
 - (a) Melting could be analogous to motor action in TGD sense. ZEO suggests that gel sends negative energy to a receiver able to receive it and in this manner gets the energy needed to perform the motor action [L93]. Nanoparticle chain would be the receiving system. Nanoparticle chains would receive their energy during heating. In the model of experimenters nanoparticle chain would serve as a memory element rather than battery.
 - (b) MB could induce transfer of positive energy from nanoparticle chains to gel. One would have only "small" state function reductions analogous to weak measurements and time evolution would be a sequence of unitary evolutions involving only weak measurements [L77, L116]: self as a generalized Zeno effect is the manner to state in the framework of TGD inspired theory of consciousness.

14.7 The emergence of human brain like functions in neuromorphic metallic nanowire network

The popular article "Human Brain-Like Functions Emerge in Neuromorphic Metallic Nanowire Network" published in Scitechdaily (http://tinyurl.com/v8a2pqg) represents findings, which are very interesting from TGD point of view. The original article "Emergent dynamics of neuromorphic networks" by Diaz-Alvarez et al is published in Nature [D8] (http://tinyurl.com/v44rc62). There are also other findings suggesting that simple systems such as plastic balls can exhibit life-like properties. In the sequel the TGD inspired model [L71, L100] for these findings is applied to neuromorphic networks.

14.7.1 Findings

Consider first the findings.

1. One can say that the self-organization process corresponds to the system "struggling" to find optimal current pathways. This process involves fluctuations akin to those found in memorization, learning and forgetting processes of brain. The temporal flutuations also resemble the processes by which brain becomes alert or returns to calm. 2. The metallic Ag nanowires become coated with a polymer (PVP)(http://tinyurl.com/ tnmu4y9) insulating layer with about 1 nm thickness. Also metallic junctions between two nanowires acting as a resistive elements analogous to synapse are formed. The average diameter and length of nanowires was measured to be 360 ± 110 nm and $14 \pm 5 \mu$ m, respectively.

Remark: These scales correspond to biological length scales (p-adic length scales L(161) and L(172)).

- 3. There are suggestive connections with biology. PVP polymer is an organic compound with repetive active part which consist of two parts: CH₂ and aromatic Carbon 5-cycle with one C replaced with N and one CH₂ replaced with C=O. In TGD framework this could be relevant for the self-organization maybe the magnetic bodies of PVP polymers are in an essential role. I have proposed that valence bonds correspond to flux tubes with effetive Planck constant $h_e f f = n \times h_0 > h = 6h_0$ [L70] (http://tinyurl.com/ycg94xpl).
- 4. The formation of low resistance pathways between probes contacting the networks induces a transition from low conductance state to high-conductance state at given voltage threshold usually below 10 V. This occurs even for millimeter distance between probes. The weak independence on voltage suggests that the current flow is almost dissipation free could dark supra currents at magnetic flux tubes be involved?

14.7.2 TGD based model

TGD predicts several a lot of new physics possibly relevant to the findings [L112, L107] (http://tinyurl.com/wd7sszo) and http://tinyurl.com/y3xbkokb).

- 1. Magnetic flux tubes (magnetic body, MB) carrying dark matter as phases with effective Planck constant $h_{eff} = n \times h_0$.
- 2. Zero energy ontology (ZEO) allows to formulate quantum measurement theory without paradoxes. The possibility of time reversal is one dramatic prediction. Basic mental functions like memory would be completely universal phenomena and possessed in principle even by elementary particles. Both memory recall and motor action would involve "big" (ordinary) state function reduction (BSFR) changing the arrow of time. Biological death would correspond to BSFR.

Sensory perception assignable to "small" state function reductions (SSFRs) identifable as correlates of "weak" measurements would not involve change of the arrow of time: the increase of distance between tips of causal diamon (CD) in each SSFR following unitary evolution would give rise to the experienced flow of time and correspondence between subjective time as sequences of SSFRs and geometric time as temporal distance between the tips of CD.

3. Universality of cognition described in terms of p-adic (adelic physics) is predicted [L75, L74, L87] (http://tinyurl.com/ycbhse5c and (http://tinyurl.com/yyyk6fu8)). Number theoretic vision realized as adelic physics predicts evolution as increase of the dimension of extension of rationals characterizing basic building bricks of space-time as surface.

Self-organization involves generation of coherence and requires energy feed [L107] (http://tinyurl.com/y3xbkokb). Same applies to life. Self-organization would be also universal: the self-assembly aspect of self organization would be simply due dissipation at reverse time direction at the level of dark matter at magnetic body controlling the dynamics at the level of ordinary matter as master.

4. Quantum criticality is essential element of self-organization and the observed 1/f fuctuations could be interpreted as their signature. Note that 1/f fluctuations are observed also in the ordinary electric circuits and since also these involve self-organization aspects, dark matter in TGD sense might be involved.

At quantum criticality long range fluctuations take place and correspond to the creation of phases with large h_{eff} and having therefore long quantum coherence length. Energy feed is however required and serves as analog of metabolic energy. Freezing of water could a

good example about quantum criticality at the level of MB inducing ordinary criticality and leading to generation of complex structures at the level of ordinary matter. Snowflakes (http: //tinyurl.com/wg8fyth) and the patterns observed by Emoto [L95] (http://tinyurl.com/ ycdywctw) as a response to stimuli like emotional voices provide examples of this.

Consider now a possible TGD based interpretation.

- 1. The voltage feeds metabolic energy to the system by making current flow possible. The transition to high conductance state above critical voltage could correspond to minimal metablic energy feed needed to induce a phase transition generating Cooper pairs of electrons or even dark Ag ions with $h_{eff} > h$ at magnetic flux tubes so that current would become partially dark and conductance would increase. The preservation of dark phase requires energy feed but the reduction of dissipation for supracurrents makes this possible.
- 2. Ag⁺ have cyclotron frequency of 2.8 Hz in "endogenous" magnetic field $B_{end} = .2$ Gauss assigned with living systems tentatively identified as the dark monopole flux carrying part of the Earth's magnetic field with nominal value $B_E = .5$ Gauss. Are the Cooper pairs of these ions involved? What about electronic Cooper pairs with cyclotron frequency about .6 MHz? Could the Coulomb energy $E_c = ZeV$ for Cooper pair in critical voltage correspond to the cyclotron energy of the dark Ag⁺ Cooper pair or of electronic Cooper pairs? Nottale hypothesis $h_{eff} = h_{gr} = GMm/v_0$ [E1] is an essential part of the TGD based model of quantum biology [L115] (http://tinyurl.com/rw58zaz) and would predict that cyclotron energies would not depend on the mass of the charged particle.
- 3. EEG is basic aspect of brain function of vertebrates. Could it be that Ag⁺ ions and also the possible ionization of the aromatic cycles make possible analog of EEG around 2.8 Hz?

In this framework the findings discussed in the article could be assigned with system which are very simple life forms. To gain improved understanding a model for the magnetic body of the system would be needed.

Chapter 15

Dance of the honeybee and new physics

15.1 Introduction

For more than two decades ago mathematician Barbara Shipman made rather surprising finding while working with her thesis [A9, A10]. The 2-D projections of certain curves in flag manifold $F = SU(3)/U(1) \times U(1)$ defined by the so called momentum map look like the waggle part of the dance of the honey bee (see http://tinyurl.com/c7pljpw). Shipman found [A8, A11, A7] that one could reproduce in this framework both waggle dance and circle dance (special case of waggle dance) and the transition between these occurring as the distance of the food source from the nest reduces below some critical distance of about 10-20 meters. Shipman introduced a parameter, which she called α , and found that the variation of α allows to integrate various forms of the honeybee dance to a bigger picture. Since SU(3) is the gauge group of color interactions, this unexpected finding led Shipman to as whether there might be a profound connection between quantum physics at quark level and macroscopic physics at the level of honeybee dance.

The average colleague of course regards this kind of proposal as crackpottery: the argument is that there simply cannot be any interaction between degrees of freedom in so vastly different length scales. This argument actually resembles the argument of nuclear physicists against "cold fusion" and is based on the dogma of length scale reductionism. Personally I however found this finding fascinating and wrote about the interpretation of this finding in the framework of TGD and TGD inspired consciousness [K59, K48].

During more than two decades a lot of progress has taken place in TGD, in particular I have learned that flag manifold F has interpretation as twistor space of CP_2 and plays a fundamental role in twistor lift of TGD [K132, K57, L76, K19]. Hence, when Johan Frisch contacted and asked whether I could help him to get material about the work of Shipman, I got interested in honeybee dance and realized that the earlier picture could be made much more detailed. I am grateful for Jerry Decker for finding links and references to the work of Shipman from web.

It is appropriate to begin by summarizing the new elements of TGD relevant for the honeybee dance.

- 1. In TGD framework an entire hierarchy of scaled variants of QCD like physics is possible by p-adic length scale hypothesis stating that preferred p-adic length scales $L_p \propto \sqrt{p}$ correspond to primes $p \simeq 2^k$. This hypothesis was inspired by the success of p-adic mass calculations [K86, K74]. In particular, in biologically especially relevant length scale range from 10 nm (cell membrane thickness) to 2-5 μ (size of cell nucleus) as many as 4 candidates for scaled variants of QCDs could exist: they would correspond to Gaussian Mersennes $M_{G,k} =$ $(1 + i)^k - 1$, k = 151, 157, 163, 167. The existence of so many Gaussian Mersennes in so narrow a length scale range is a number theoretical miracle. The interaction of honeybee could be with scaled up variant of QCD like physics and the quarks could have the size of cell nucleus!
- 2. The flag manifold $F = SU(3)/U(1) \times U(1)$ has an interpretation as the space for the choices

for the quantization axes of color quantum numbers (color hypercharge and isospin). Few years ago it turned out that F is the twistor space of CP_2 and possesses Kähler structure [K132, K19, L76]. As a matter of fact, S^4 and CP_2 are the only compact spaces with twistor space possessing Kähler structure. Also M^4 and E^4 - kind of non-compact variants of S^4 - allow twistor space with Kähler structure (M^4 in generalized sense). Hence the existence of twistor lift of TGD implies that TGD is completely unique.

TGD inspired theory of consciousness [K76] leads to a proposal concerning the identification of qualia [K59]. One can distinguish between non-geometric qualia - colors, tastes, and odours - and geometric qualia representing geometric information such as angles and distances. Flag manifold qualia would be universal "general purpose" geometric qualia representing geometric information. In the model for the honeybee dance the point of 6-D flag manifold F would represent positional information about the food source and waggle dance would represent this point of F as a dynamical pattern very much like the point of momentum space is represented as orbit in configuration space.

3. TGD predicts hierarchy of Planck constants $h_{eff}/h = n$ labelling the levels of a dark matter hierarchy identified as phases of ordinary matter residing at flux tubes of magnetic bodies (MBs) assignable to ordinary physical systems. In the adelic vision h n corresponds to the dimension of the extension of rationals defining particular adele in the hierarchy of adeles having interpretation in terms of an evolutionary hierarchy [L74] [L75]. The scaling of Planck constant by n means similar scaling of Compton lengths implying zooming up of the microscopic physics. These scaled up variants of particles at the MB of the living system play a crucial role in TGD inspired quantum biology, and even suggests new physics associated with the notion of valence bond highly relevant to metabolism [L70] (see http://tinyurl.com/ycg94xpl).

This background gives good motivations for looking whether Shipman's findings could make sense in TGD Universe. It however turned out difficult to find any material relating to Shipman's work in web and the popular articles do not tell the details. There are several questions to be answered.

What do momentum map and 2-dimensional projection really mean? What the curves studied by Shipman really are?

- 1. Momentum map μ is a standard notion and actually familiar for physics albeit being represented using totally different language. In the case of general Lie group G acting as symmetries of symplectic manifold M, μ maps the elements of g (su(3) now) represented as vector fields of M or the images of corresponding one-parameter groups (flows) to the elements of the co-adjoint algebra g^* of g having Poisson structure. One-parameter groups associated with the elements of g are mapped to conserved Hamiltonians associated with them. Mathematician speaks of co-adjoint orbits as images of orbits in M.
- 2. Physicist would see the situation either at the level of configuration space ("q-space") or momentum space ("p-space"). Exponential map takes each element X of Cartan algebra $h \subset g$ to an image of corresponding one-parameter group by exponential map, the orbit of the flow defined by X.

Since M allows symplectic structure and G acts as symmetries, each orbit is characterized by conserved Hamiltonians associated with elements of g. Only the Hamiltonians assignable to h commute with respect to Poisson bracket.

The image of H in M is spanned by 1-parameter subgroups associated with H. In momentum space picture given orbit corresponds to single point in co-adjoint algebra g^* defined by the two conserved Hamiltonians defining the momentum of the particle.

3. The choices of H are labelled by flag manifold F and each point of F defines a 2-momentum in h^* . The projection of F to h^* defines so called momentum polytope, which is hexagon. This notion makes sense completely generally.

What could be the TGD counterpart of this general picture? Consider first the general dynamics.

1. In TGD framework the new element is that the 2-D image Y of $U(1) \times U(1) \subset SU(3)$ in CP_2 is further projected to the space-time surface $X^4 \subset M^4 \times CP_2$: one simply forms the intersection $X = Y \cap X^4$. X (as already Y) carries vanishing induced Kähler form being thus analogous to Lagrangian sub-manifold. X is also analogous to the so called Chladni surface at which electric field vanishes: the physical meaning of these surfaces is discussed in [L46].

The dynamics of the twistor lift of Kähler action [K132, L76, K19] reducing to a 4-D generalization of a dynamics coupling geodesic motion of point particle to induced Kähler field (analogous to Maxwell field) would fix space-time surfaces and therefore also the surfaces X. This dynamics could be also seen as a generalization of Chladni mechanism. Asymptotic selforganization patterns indeed correspond to the vanishing of the induced Kähler force inside given space-time sheet. These space-time regions correspond to external particles entering CD in ZEO based view about scattering. At point-like limit the external particles would be geodesic lines and in interaction regions move under Kähler force.

2. In the general case the dimension D(X) of X satisfies $D(X) \leq 2$. One can have D(X) = 2 if space-time surface carries vanishing induced Kähler form: these surfaces are special case of minimal surface extremals for the twistor lift of Kähler action [K19] [L43].

There are also other kinds of preferred extremals. Cosmic string solutions are of form $X^2 \times S^2 \subset M^4 \times CP_2$, where X^2 is minimal surface - string world sheet and S^2 is geodesic sphere of CP_2 . CP_2 has two non-equivalent geodesic spheres. The first one has vanishing induced Kähler form and second is homologically non-trivial (non-contractible) and carries Kähler magnetic flux.

One has also more general preferred extremals $X^2 \times Y^2$, where Y^2 is complex sub-manifold of CP_2 obtained by replacing S^2 with a sphere with $g \ge 1$ handles. These flux tubes are infinitely thin but one can deform them in M^4 directions to get magnetic flux tubes of finite thickness, which are key players in TGD inspired quantum biology.

3. The proposal is that simple modifications of these extremals exist as preferred extremals. One can "kick" Y^2 in rotational rigid body motion in CP_2 such that there are separate rotations in temporal and spatial directions of X^2 . The surface X would be 2-D projection of $U(1) \times U(1)$ to X^2 . Symmetry breaking can occur and reduce the projection esentially to that for $U(1) \subset U(1) \times U(1)$, and one obtains a unique waggle run along flux tube. Note that this ansatz works also for the M^4 deformations of cosmic strings.

Surfaces X at string world sheets X^2 or equal to them would thus serve as representations for the points of F.

What about the details of the waggle dance?

1. Additional information such as waggling can be coded by the dynamics of the modified $X^2 \times Y^2$ with rotating Y^2 deformed in M^4 degrees of freedom. X has one time-like direction so that the two waggle runs must correspond to two distinct points of F related by a symmetry realized as a reflection with respect to the line connecting the hive to the food source (the two waggle runs give rise to a V shape with edges representing the horizontal projection of the line to the food source).

The necessity of the crucial phase transition from waggle dance to circle dance (special case of waggle dance) follows actually without any assumption about the model for the proposed coding of position information about food source.

- 2. The temporal duration assignable to X defines naturally the duration of the waggle dance in turn coding for the distance of the food source and identifiable as TGD counterpart for the parameter α of Shipman.
- 3. Waggle run involves two important frequencies: vibration frequency f_v of wings and waggle frequency f_w : these frequencies could correspond to the two conserved Hamiltonians essentially frequencies (f_1, f_2) associated with the waggle run.

In the sequel I will summarize some basic facts about honeybee dance, sum up what I understand from the work of Shipman, and discuss the TGD based model and compare it with Shipman's work. The TGD inspired model is inspired by the twistor lift of TGD giving special status for the twistor space of CP_2 as flag manifold $F = SU(3)/U(1) \times U(1)$, by the general vision provided by TGD about living matter, by the TGD based model for qualia, by the basic knowledge about honeybee dance - in particular the intriguing observation the two basic frequencies associated with dance correspond to cyclotron frequencies - , and by the interpretation of the findings of Shipman.

Before continuing it is appropriate to list references to Shipman's work. Work related to Toda lattices can be found at [A9, A10]. There are also articles in arXiv (see http://tinyurl.com/y998f9v6, http://tinyurl.com/yapgjprt, and http://tinyurl.com/y7a47f39). The work related to honeybee dance can be found in the articles [A11, A7].

15.2 Some empirical facts

The background for TGD based proposal concerning the dance of honeybee relies on some key empirical facts and the attempt to understand the intriguing findings of Barbara Shipman in TGD framework.

There are articles in ScienceDirect discussing waggle dance from the perspective of neuroscience (see http://tinyurl.com/ycuhjybt). For instance, "Dance Language" by Dyer and "Learning Theory and Behaviour" by Marco and Menzel are warmly recommended.

The beginning of the article of Dyer gives some idea about the importance of the decoding of waggle dance by Frisch.

Anyone who has watched bees dance for food, and is aware of the function of this behavior, cannot help but be amazed. Karl von Frisch's decoding of the dance language is certainly one of the great discoveries in modern biology. This is not only because of the inherent fascination that the dance holds for curious human observers. Even more important is the extent to which von Frisch's discovery laid the foundation for the study of deep questions about animal behavior. When we consider the role that the dance language has played in the study of vision, olfaction, audition, learning, circadian rhythms, decision making, social organization, and behavioral evolution, it is easy to see why von Frisch regarded the dance language as a 'magic well' of discovery. Furthermore, with advances in neuroscience, genomics, and evolutionary theory, it seems clear that the value of the dance as a model system will continue for many years to come.

From this it is clear that waggle dance involves multi-sensory communications including vision, hearing, and olfaction. There are several questions to be answered. What information does the dance convey? How the dancer gathers this information? How the audience extracts this information from the dance? The basic puzzle is how an insect with so small cognitive capacity (no cortex nor limbic brain) is able to carry out this feat?

Swarm intelligence is proposed as an answer: this would not involve consciousness. I would be surprised if deep learning were not proposed as a solution. But is this enough? Should one consider bee as part of larger conscious entity - the hive - just like one regards single neuron as part of brain? And what about cognition: should one have genuine theory of consciousness describing also cognition: the formulation of TGD as adelic physics indeed provides a theory of cognition [L75] [L74].

15.2.1 Basic facts about the dance

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" [J109].

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 waggling 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 waggling parts of the dance correspond to two disjoint straight line portions located at the opposite sides of the hexagon.

Besides waggle dance and circle dance as special case of waggle dance there are also other forms of honeybee dance such as tremble dance and grooming dance.

One can find summary about more quantitative empirical facts related to the waggle dance in Wikipedia (see http://tinyurl.com/c7pljpw). The following represents some facts relevant to the updated TGD inspired model are listed.

- 1. Waggle dance involves 100 or more circuits. The duration of the straight portion, waggle run, depends on distance: according to Wikipedia 1 second corresponds to 1 km. This might make sense at long enough distances but for short distances in the range 10-20 m this would mean millisecond time scale and this cannot make sense.
- 2. The dance language codes positional information about the food source (this need not be the only information: also information about the quality of the nectar might be represented). The direction of the food source relative to Sun is coded to the direction of relative to the direction of gravity (vertical direction). The polar angle θ_S with respect to the direction of Sun is mapped to polar angle $\theta_{gr} = \theta_S$ with respect to the vertical direction defined by gravitational force. The atzimutal angle ϕ with respect to the projection of the solar direction to the horizontal plane is represented as such.

The distance d of the food source is coded to the duration, call it T - of the waggle period and also to the number of wagtail movements during single waggle run (this is trivially true if the wagtail movements occur with same frequency f_w always). Also the vibration frequency f_v of wings correlates with d. One has $f_w \simeq 13$ Hz and $f_v \in [200, 300]$ Hz.

Remark: These frequencies are not too far from cyclotron frequencies $f(Ca^{2+}) = 15$ Hz and f(p) = 300 Hz in endogenous magnetic field $B_{end} = 0.2$ Gauss explaining the quantal effects of ELF radiation on vertebrate brain [J23] [K100, K101].

3. What is remarkable that the orientation information - that is the values of θ and ϕ - is automatically updated to take into account the motion of the Sun. In brain as a computer paradigm this would require quite impressive computation taking into account the size of the brain of honeybee (no cortex and no limbic brain). Even humans are unable to perform this feat. Deep learning paradigm might help but personally I remain skeptic.

15.2.2 How forager bee could collect the position information?

Honeybee dance mediates information about both the direction and distance of the food source. In neuroscience approach identifying brain as a computer this information would be stored by computation. The proposal is that the foraging bee utilizes solar compass. The information about the direction in the plane of Earth would be stored by using the information extracted from the polarization of the sunlight. The cloud free regions can provide this information even in cloudy day.

It has been proposed that the information about the distance of food source is coded by the net motion of the visual features of environment along retina during the flight. Experimentation has shown that it is the projected distance to the food source (rather than absolute distance) which is coded in this manner.

During flight bee develops positive electromagnetic charge, call it Q, to its abdomen. The charge is due to moving and rubbing together of the body parts. Also Q serves as a measure for the distance of the food source (see http://tinyurl.com/y8vcqc7n and http://tinyurl.com/ycn32wrk).

Interestingly, the pollen in flowers is negatively charged relative to environment and sticks to positively charged bees. The electric field of flow changes for 100 seconds after the visit of bee to prevent from futile visits. Bees also detect the electric field created by flower possessing negative charge relative to environment. Bees also detect electric oscillations.

15.2.3 Communications in other sensory modalities

Dance language is not purely visual. There are also communications in sensory modalities other than vision. Dancing bee produces and releases hydrocarbons: two alkanes, tricosane and pentacosane, and two alkenes, (Z)-9-tricosene and (Z)-9-pentacosene, onto their abdomens and into the air. This makes possible communication by olfaction.

Also acoustic and electromagnetic communications are involved.

- 1. During dance sounds with frequencies f_v in the range 250-300 Hz are emitted from the vibrations of the wings. Flight sounds are in the same frequency range. It is reported (see http://tinyurl.com/y8qklrhx) that there is a preferred value of f_v around 265 Hz. Honeybees also prefer rhythmic sounds. These preferences allow to detect the sounds produced by honeybee dance in dark and noisy environment.
- 2. The value of f_v correlates with the distance of the food source decreasing with the distance (see http://tinyurl.com/ya4kq8b8). In the example discussed in the article f_v decreases from 315 Hz to 207 Hz at interval 50-1600 m. Also the duration of the wag run and the number of wagtail movements during the run increase with the distance.

This vibration mediates auditory information. Acoustic oscillations can be however transformed to electromagnetic vibrations in the body of honeybee since living systems are piezo electrets. The antennae of bees are sensitive to em radiation at ELF frequencies.

3. The frequency f_w of lateral swinging of the body of dancer is reported to be 13 Hz (see http://tinyurl.com/ycsmlxt7). This frequency is below the consciously audible range in the case of humans but also now the transformation to electromagnetic oscillations is possible. During waggle run electric fields are emitted and a natural expectation is that the frequencies f_v and f_w define important electromagnetic frequencies.

What is intriguing is that f_w is in EEG range. As already observed, f_v and f_w could correspond to cyclotron frequencies of proton and Ca^{2+} in a magnetic field near to the endogenous magnetic field $B_{end} = .2$ Gauss needed to explain the quantal effects of ELF em fields in vertebrate brain.

Could radiation with frequencies in EEG range be important also in beehive? For years ago I asked the crazy question whether beehive could have the analog of EEG communicating information from beehive to its MB and making possible the control of beehive by MB using cyclotron radiation. The condition that cyclotron frequencies for MB are identical with some relevant frequencies of biological body is essential for resonance making possible communication and control.

15.3 The findings of Shipman

A popular article describing the findings of Barbara Shipman [A8, A11, A7] related to honeybee dance can be found at web (see http://tinyurl.com/96kzbw). These are however difficult to find. There are also articles about Toda lattices [A9, A10], which she studied in her thesis (see http://tinyurl.com/yde7h6q4).

The basic notions used by Shipman relate to the theory of symplectic manifolds M with symmetry group G. The notion of flag manifold is in an essential role. Moment(um) map to the co-adjoint g^* of the Lie algebra g having symplectic structure is involved. Also projections to the Cartan algebra $h \subset g$ and its image in M and to the co-adjoint h^* of the Cartan algebra of G are involved. These notions are standard.

What about the particle dynamics having curves as orbits? This question one cannot be answered firmly without access to the work of Shipman but I failed to find the work of Shipman in web anymore. The natural guess is however that the orbits correspond to actions inf M of oneparameter subgroups of G parameterized by g, which for symmetric spaces such as CP_2 correspond to geodesic lines. The subset of M spanned by the orbits assignable to the elements of $h \subset g$ is therefore a natural object.

Shipman studies in her thesis "Convex polytopes and duality in the geometry of the full Kostant-Toda lattice") (see http://tinyurl.com/yde7h6q4) the dynamics of Toda lattices. These systems are completely integrable systems and Shipman uses generalized flag manifolds for this purpose. The groups involved are non-compact and have non-trivial Borel sub-groups (consisting of matrices with vanishing lower diagonal). I have briefly summarized the ideas related to Toda lattice in [K59].

It however seems that in the applications to honeybee dance one can study SU(3), which is compact. For SU(3) the Borel sub-group would formally reduce to $U(1) \times U(1)$ consisting of diagonal matrices.

Momentum map seems to be very general and allows very general dynamics. What is needed is that one can assign to each point of the orbit values of Hamiltonians $H_i = \mu(X_i)$ defined as contractions of vector fields X^i with the 1-form μ . The Hamiltonians of Cartan algebra commute with respect to Poisson bracket and therefore it is natural to consider the orbits for which these Hamiltonians are constant in Hamiltonian dynamics having G as symmetries. It would however seem that co-adjoint orbit (it would not reduce to a point for non-Hamiltonian dynamics) and its Cartan projection are always well-defined: even when the dynamics itself is not Hamiltonian and Hamiltonians are not conserved.

15.3.1 Dance of the honeybee

The following piece of text is summary of Shipman's findings that I wrote as I proposed g the TGD inspired model for honeybee dance in [K59]. It must be emphasized that the model to be discussed differs from this model introduced for more than twenty years ago. I cannot guarantee that Shipman would agree with all what I claim.

What Barbara Shipman found [A8] 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 [A8] it seems 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 [A9, A10].

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 $SU(n)/U(1)^{n-1}$ 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 (see http://tinyurl.com/ybds7us2): 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.

Remark: The recent TGD inspired model to be discussed deviates from this picture since the intersection X of Shipman's projection with space-time surface defines the parquette for D(X) = 2 and also the dance for D(X) = 1.

15.3.2 Basic mathematical notions

It is appropriate to introduce the basic mathematical notions used by Shipman although the TGD based model is formulated without using these notions explicitly: the dance parquette is identified as the surface $X \subset X^4$ defined as the intersection of X^4 with the orbit of $U(1) \times U(1)$ in CP_2 . For D(X) = 1 dance parquette reduces to dance pattern. For given orbit $U(1) \times U(1)$ the Hamiltonians associated with $u(1) \times u(1)$ Lie-algebra generators are constant.

1. The definition of the moment(um) map can be found from Wikipedia. One considers manifold M with symplectic structure and allowing group G as isometries. Any element of Lie-algebra g of G can be represented as a vector field X of M giving rise to orbits by exponential map. If X is symplectic transformation, the one parameter group associated with X is represented as orbit in M obeying Hamiltonian dynamics defined by the conserved Hamiltonian H(X) assignable to X.

At any point of M can map X(x) to the dual g^* of g (co-adjoint of g) by contracting it with symplectic form J defining the symplectic structure. Momentum map gives just the Hamiltonian H(X) associated with X. One starts from the formula

$$d\langle \mu, X \rangle = dH(X)$$

for the contraction between 1-form μ and vector field X. Clearly, the Hamiltonians are defined only modulo additive constant. Along the orbit of the flow defined by X H(X) is constant since one has Hamiltonian flow

$$\frac{dY}{dt} = \{H, Y\}$$

applied to Y = X. Also the Hamiltonians associated with Lie-algebra generators commuting with X are constant along the orbits of X.

One can define momentum map as one-form μ by requiring that the value of μ at point x of M for any X equals to Hamiltonian H(X) at this point:

$$H(X(x)) = \langle \mu(x), X(x) \rangle$$
.

Since the number of components of μ is the dimension D(M) of M and g is D(g)-dimensional, this gives D(M) equations for D(N) > D(M) variables so that solutions exist. The condition that the Poisson brackets of Hamiltonians represent the Lie-algebra gives additional conditions allowing to fix μ .

- 2. Momentum map allows to assign to the orbits of the dynamical system obeying Hamiltonian dynamics conserved Hamiltonians and for completely integrable systems such as Toda lattice these conserved Hamiltonian fix the solution completely.
- 3. The Cartan sub-algebra h of g determines maximal number of commuting conserved quantities quantum mechanically and one can assign to the image of the classical system in g^* its projection to h^* . In TGD framework one can however argue that this does not provide an interesting representation of the waggle dance since a stationary position of the bee at dancing parquette would code for the position information.

Rather, it would seem that the dual of this representation in which point of h^* determines the direction and magnitude of the momentum/velocity of the bee is more appropriate. One can also indeed h as a union of orbits of generators of h in M. Waggle run would correspond to one particular point of h. The Hamiltonians associated with vector fields of h would be constant at this surface.

4. The projection of flag manifold to the image of h in flag manifold $F = SU(3)/U(1) \times U(1)$ or any manifold M, say CP_2 with symplectic SU(3) action would determine the 2-D dance parquette for G = SU(3). At these 2-surfaces orbits would be parameterized by constant values of Hamiltonians defining color hypercharge and isospin. The choices of the subgroup $U(1) \times U(1)$ are parameterized by F and at each surface. As already noticed, one must consider the intersection of this set with space-time surface in TGD framework.

One could say that the points of F representing the choices of quantization axes for color quantum numbers are represented by 2-D Lagrangian surface in CP_2 in TGD framework. This would realize quantum classical correspondence realizing the quantization axis as a dynamical pattern. As noticed, the projection to space-time surface need not be 2-D.

5. The projection map of F = G/H to h^* defines so called momentum polytope having dimension of h (see http://tinyurl.com/ycxddqz5). In the case of SU(3) polytope is 2-D hexagon. The fact that behave has the structure of hexagonal lattice is taken by Shipman as an accident but one can ask whether this is really so.

15.4 TGD based model

The purpose of honeybee dance is to represent symbolically a behavioral pattern leading to a desired goal, a kind of a program. In ZEO behavioral patterns are fundamental whereas time=constant snapshots of dynamics are fundamental in standard positive energy ontology (PEO). ZEO is extremely restrictive: the preferred extremals of the action principle satisfy infinite number of additional gauge conditions reducing the effective number of space-time dimensions to 2 corresponding to the strong form of holography.

Number theoretic approach [L75, L74] forces even stronger form of holography: in which finite measurement resolution is a key aspect of dynamics reduces the locus of initial values to a set of discrete space-time points providing a cognitive representation for the system at space-time level [L66]. This picture conforms with the computationalistic idea that that finite number of numbers fixes the time evolution as an analog of computer program [L63].

The idea that forager bee would perform complex neuronal computations to store the data about the path to the food source looks to me somewhat questionable. At least these computations involved cannot be conscious. AI enthusiast would propose deep learning as a formation of associations leading to the miraculous ability of the bee to remember the path and represent it by dance pattern. This option looks more promising.

To me a more plausible view to consider is that the positional information is stored automatically to the MB of honeybee. This brings in the radical possibility that the forager bee actually generates temporary flux tube connections with the food source and has a permanent contact with Sun and Earth via gravitational flux tubes. This would store the information to the MB of the bee and the updating would be automatic.

15.4.1 Some ideas of TGD and TGD inspired neuroscience and quantum biology

One should be able to model honeybee dance without introducing any adhoc assumptions. In particular, the dance itself should emerge at space-time level from the fundamental dynamics of TGD. Central notions are ZEO and magnetic body (MB) carrying dark matter as $h_{eff} = n \times h$ phases of ordinary matter. This hierarchy has first principle description in terms of adelic physics [L75, L74].

Zero energy ontology

TGD inspired theory of consciousness and quantum biology rely on few key ideas and notions. Zero energy ontology (ZEO) is of them. ZEO leads to an extension of quantum measurement theory to a theory of consciousness [L77]. The notion of causal diamond (CD) plays a key role in ZEO. ZEO implies that time=constant snapshots as counterparts of physical states are replaced by preferred time evolutions as 3-surfaces (analogs of Bohr orbits) connecting the 3-surfaces at the opposite light-like boundaries of CD analogous. Zero energy states states can be regarded as events with initial and final states at opposite boundaries of CD and classically represented as 3-surfaces.

Field equations in the twistor lift of TGD [K132, L76, K19] can be regarded as a generalization of the dynamics of geodesic motion coupled to Kähler force obtained by replacing 1-D curve with 4-D orbit X^4 of 3-surface. The preferred extremals can be divided to two kinds of regions. Regions of first kind represent external particles for which Kähler 4-force vanishes and which are minimal surfaces as analogs of light-like geodesics. Regions of second kind are interaction regions inside CDs where the Kähler 4-force is non-vanishing. Following biologists and neuroscientists one could speak about a generalization of the notion of behavioral pattern or biological function. Computer scientist would talk about programs.

In ZEO the act of free will would be analogous to a replacement of a deterministic program with a new one [L63]. ZEO is actually forced by the acceptance of the fact that we have free will, which must be consistent with the determinism of field equations. At quantum level, classical program as preferred extremal is replaced with a quantum superposition of classical programs, which in some resolution cannot be distinguished from each other.

The notion of magnetic body

The basic distinction between TGD and Maxwell's electrodynamics and gauge theories is that in TGD Universe any system has a field identity as separate space-time sheets, topological field quanta. They correspond to magnetic flux sheets or tubes and also to electric field has topological quanta. This follows from the notion of the induced gauge field. In Maxwell's theory fields of different systems interfere, in TGD they correspond to separate space-time sheets but particle experiences the sum of the forces caused by them since it touches these space-time sheets.

This modification forces the replacement

 $organism + environment \rightarrow MB + organism + environment.$

MB receives sensory input from biological body (BB) and controls it. Sensory input to MB can be in terms of generalized Josephson radiation from cell membrane acting as generalized Josephson junction and coding nerve pulse patterns to frequency modulations. The control by MB can be realized in terms of cyclotron radiation to DNA (accompanied by what I call dark DNA [L44]).

Hierarchy of Planck constants

The hierarchy $h_{eff} = n \times h$, n = 1, 2, 3, ... of Planck constants gives rise to a hierarchy of dark matters. $h_{eff} = n \times h$ labels the onion like layers of MB. The size scale of give layer is by uncertainty principle of order of cyclotron wavelength $\lambda \propto m/eB$ and thus proportional to particle mass m. The value of Planck constant determines the hierarchy level: n can be identified as the dimension of the algebraic extension of rationals defining the adele [L75], and measures the complexity of the

algebraic extension associated with the dynamics at the basic level, and therefore serves as a kind of IQ. Evolution corresponds to a gradual and unavoidable increase of $h_{eff}/h = n$ in statistical sense.

- 1. At the atomic level the value of n seems to be n = 6 rather than n = 1 [L70, L52]. For valence bonds the value of n is already larger and increases along the rows of the periodic table being largest for the molecules containing atoms towards the right end of the period: biologically important atoms C, N, O, S, P are examples associated with valence bonds with large n.
- 2. For protons at hydrogen bonds the value of n is much higher than for electrons of valence bonds and the generation of hydrogen bonds could be seen as a crucial aspect of bio-chemistry. Metabolic energy is measured as the difference of the energy of bond for ordinary value of h_{eff} from the real one and one can say that metabolic energy provides for the system ability to increase its negentropy. Metabolic energy increases h_{eff} resources: this is why we must eat.

An important additional hypothesis generalizes the notion of gravitational Planck constant due to Nottale [E1].

1. The hypothesis [?, K95] states that at the flux tubes mediating gravitational interactions (propagation of gravitons) one has

$$\hbar_{eff} = n\hbar = \hbar_{gr} = \frac{GMm}{v_0}$$

where M and m are the masses associated with the ends of the flux tube and $v_0 < c$ has dimensions of velocity. This formula holds true if Mm/v_0 exceeds Planck mass squared and implies that the coupling parameter GMm in perturbation series is replaced with $v_0/c < 1$ so that one achieves convergence.

- 2. For large values of M the value of h_{gr} can be very large, which means that long range gravitational interaction can give rise to systems with very high cognitive resources. This hypothesis generalizes also to other interactions in rather obvious manner and the phase transition increasing the value of h_{eff} leads to dark phase in which perturbation theory converges (the value of the coupling strength $\alpha \propto 1/\hbar_{eff}$ is reduced).
- 3. The value of M depends on the state of the network defined by the flux tubes mediating gravitational interaction. At the limit of ordinary quantum gravity M would be mass of elementary particle. There is however entire dynamical fractal hierarchy of gravitational flux tubes completely analogous to those postulated flux tube hierarchies in neural system and in endocrine system. For instance, the fountain effect of superfluidity could correspond to a situation involving large value of h_{gr} . In living matter the mass of large neuron is of order Planck mass and defines kind of critical mass in the sense that gravitational interaction between two large neurons could correspond to h_{gr} .
- 4. $h_{eff} = h_{gr}$ hypothesis implies that cyclotron energies do not depend on the mass m of the charged particle and are therefore universal. The proposal is that the energy scale of bio-photons, which is in visible and UV appropriate for molecular transitions, corresponds to the energies of dark cyclotron photons, which can transform to bio-photons [K20]. The spectrum of the values of "endogenous" magnetic field B_{end} with nominal value $B_{end} = .2$ Gauss would corresponds to the energy range of bio-photons. Cyclotron photons would play central role in the control of biological body by MB based on resonance mechanism. Also the communications from biological body to MB would involve resonance mechanism.

Flag manifold qualia

TGD inspired theory of consciousness leads to a proposal concerning the identification of qualia [K59]. The original proposal was based on standard ontology and the sensory qualia were identified in terms of changes of quantum numbers in state function reduction: the problem of the

interpretation is that the outcome of the reduction is random and qualia could be defined only in statistical sense.

The recent view is based on the vision about self as a generalized Zeno effect [L77]. In ZEO qualia would correspond to quantum numbers measured repeatedly during the Zeno period having also interpretation as so called weak measurement.

- 1. One can distinguish between non-geometric qualia like colors, tastes, and odours, and geometric qualia representing geometric information such as angles and distances. Flag manifold qualia would be universal geometric qualia. In the model for the honeybee dance [K59] the point of 6-D flag manifold F would represent positional information about the food source and waggle dance would represent a point f of F (or an orbit inside the 2-surface of CP_2 representing f) as a dynamical pattern.
- 2. F has symplectic structure and this encourages the question whether flag manifold qualia could be divided to position type qualia and momentum type qualia. The symplectic structure of F forces to ask whether only degrees of freedom which correspond to mutually commuting Hamiltonians are representable. If so then the representations of qualia at space-time level could correspond to 2-surfaces for which Hamiltonians assignable to $U(1) \times U(1)$ are constant. Motion in this plane dictated by the values of these Hamiltonians as momenta would provide the representation of the geometric qualia at the level of CP_2 .
- 3. The natural proposal is that the surface $X \subset X^4$ obtained as intersection of space-time surface and the orbit of $U(1) \times U(1)$ in CP_2 and depending on the dimension D(X) analogous to string world sheet, curve, or even point corresponds to a kind of dance parquettes or dance itself.
- 4. In the case of M^4 twistor lift forces to introduce the geometric variant of twistor space as $M^4 \times CP_2$ and also generalization of Kähler structure and symplectic structure. The counterpart of $U(1) \times U(1)$ consists of translations in time-like plane and the point of the twistor space correspond to a choice of time axis (energy quantization axis) and quantization axis of spin.

In fact, octonionic approach to TGD reducing the dynamics of TGD to algebraic geometry forces to introduce preferred time axis and spatial axis: they correspond to octonionic real unit and preferred imaginary unit [L66]. The 6-D twistor space $M^4 \times S^2$ labelling the choice of these axes would code for geometric information, and also now one would have a representation in terms of the intersection of space-time surface with this plane.

These arguments suggest that flag manifold qualia are something very fundamental and gives support for the discovery of Shipman. Honeybee dance would provide also support for the coherence of long range classical color gauge fields predicted by TGD.

15.4.2 Waggle and vibration frequencies as clues

The basic vision is that MB uses biological body (BB) as a motor instrument and sensory receptor. Control and communication mechanisms are based on resonance mechanism requiring that the changes of energies for some transitions are same at the level of MB and BB: this gives very powerful constraints on prebiotic scenarios and allows to understand why just certain molecules were chosen as bio-molecules [L71, L80]. Cyclotron frequencies are in a special role and one expects that the resonant frequencies at the level of biological body correspond to cyclotron frequencies. Large value of h_{eff} guarantees that low frequency quanta have energies about thermal energy and therefore effective.

The fundamental dynamics would be that of magnetic flux tubes. Bee could simply move along a flux tube carrying dark ions. A more ore detailed model will be discussed later. The orbits at the image Y of $U(1) \times U(1)$ in CP_2 are labelled by two momenta, essentially frequencies since angle variables are in question. Could the frequencies (f_1, f_2) have counterparts in honeybee dance? There are indeed two key frequencies involved: waggle frequency f_w and vibration frequency f_v for the wings of the bee: could the identification $(f_w, f_v) = (f_1, f_2)$ make sense?

Some of the cyclotron frequencies involved should correspond to f_w and f_v .

1. The vibration frequency f_v for the wings of the bee varies in the range 200-300 Hz roughly. For $B_{end} = .2$ Gauss, which explains Blackman's findings about the quantal effects of ELF radiation [J23], the cyclotron frequency of Ca^{2+} would be $f(Ca^{2+}) = 15$ Hz (or its multiple corresponding to higher cyclotron transitions).

300 Hz would correspond to protons cyclotron frequency for B_{end} . For $f_c(p) = 200$ Hz the value of B would be $B = 2B_{end}/3$. f_v could correspond also to electromagnetic frequency since acoustic signals are transformed to electric signals in living matter, which consists of piezo electrets.

- 2. The observed waggle frequency f_w is around 13 Hz and suggests that B_{end} is scaled down by factor 13/15 in this case. This scaling down reduces f_v to 250 Hz. The preferred value of f_v is reported to be around 265 Hz (see http://tinyurl.com/y8qklrhx).
- 3. The average value of f_v is reported to decrease with the distance from 315 Hz at 50 m to 207 Hz at 1600 m (see http://tinyurl.com/ya4kq8b8). Therefore also the value of B_{end} should decrease with the distance. Interestingly, the lower bound $f_v = 200$ Hz corresponds to lower bound $f_w = 10$ Hz in alpha band and in the case of humans defines the lowest frequencies correlating directly with conscious experience. Alpha band indeed dominates in the transition from awake state to sleep.
- 4. These observations support the view that f_w and f_v allow interpretation as cyclotron frequencies, and force to ask whether proton and Ca²⁺ cyclotron frequencies are in key role in the communications between the dancer and the audience. It is indeed known that the dancer generates electric oscillations and the bees can detect them by their antennae. Proton and Ca²⁺ are also in a key role in the function of cells and neurons.

One cannot avoid the question whether behive could have EEG or at least alpha band. Bees should not have EEG if the usual neuroscience interpretation for EEG frequencies as being produced by cortex is correct but in TGD one cannot be certain about this.

15.4.3 What should one understand?

One can try to understand the basic topology of the dance by starting from the interpretation for the information coded by it. This does require introduction any specific model for how the information is represented.

1. Why the waggle pattern transforms from two parallel lines for large distances to V shape at shorter distances and finally to two disjoint pieces of circle dance? A possible answer is that the angle between the edge of V and its diagonal represents the angle between the direction of the food source and its projection in horizontal direction. For long distances the angle is small so that the lines are nearly parallel.

For short distances the angle becomes large. At criticality the upper edge of V becomes vertical and the dancing pattern must change since other wise the direction to the source is interpreted to opposite from the real one. Waggle periods must be in a direction parallel to the direction of food sources to code for the direction of the food source. Waggle period becomes short since it codes for a short distance.

2. Why two waggle runs - left and right run - as mirror images of each other with respect to the diagonal of V are needed. If waggle direction is actually the direction along the surface of Earth to the food source, waggle run and its mirror images are necessary for coding the information about the diagonal of V defining the direction to the food source.

Suppose that the position information about the source is represented by a point of F.

1. How the coordinates of the point of F characterizing choices of $U(1) \times U(1)$ code for the position information? The intersections X of the orbits of $U(1) \times U(1)$ in CP_2 with the space-time surface have in the generic case $D(X) \leq 2$ and should code the position information. X can (and must) have one time-like direction. For D(X) = 1 this gives just single waggle run. The temporal length T of X codes defining the duration of the waggle codes for the distance of the food source.

- 2. The parameter α introduced by Shipman correlates with distance and could code it. Since the duration of the waggle run correlates with the distance, a possible interpretation of α as temporal duration T assignable to X. Also the value of the charge Q generated during the flight and proportional to the duration of the flight is roughly proportional to the distance and thus T and α .
- 3. Waggle frequency f_w is additional dynamical parameter related to the motion of the dancer. According to Wikipedia the higher the value of f_w is, the more excited the bee is. This would suggests that f_w varies. Waggling and f_w would relate to the dynamics of space-time surface involved (flux tube perhaps) in M^4 degrees of freedom rather than to the rather simple dynamics of geodesic motion in CP_2 . Oscillating string is what comes in mind as approximation to the dynamics of the flux tube.
- 4. Vibration frequency f_v for wings is a further additional parameter. Also f_v would to the dynamics of X if the flux tube controls the motion of the bee. Cyclotron frequency hypothesis implies that the ratio f_v/f_w of waggle frequency and vibration frequency is constant equal to the mass number of Ca divided by two $f_v/f_w = A/2 = 20$.

If $(f_w, f_v) = (f_1, f_2)$ identification makes sense then also (f_w, f_v) would be coded by the point of F.

Remark: Amusingly, the same number 20 appears in the model for life like properties of a simple system of plastic balls in Argon gas: now the ratio of atomic weight of Argon and proton (A(Ar) = 20) gives it [L71] (see http://tinyurl.com/y8wexfqo). An explanation for the decrease of the f_v and (possibly of f_w too) with the distance of the food source would be needed. Could the long distance to the food source imply that the dancer is less excited? This would require the decrease of the value of B_{end} to which f_w and f_v are proportional with distance. The value of B_{end} could correspond to the magnetic field at the flux tube.

5. It seems that one can understand what happens to the position information at the criticality. One should also understand how the change of the dancing pattern is represented at the level of F and X. Why the intersections of $U(1) \times U(1)$ with space-time surface get short? Is this simply due to the fact that the temporal length of X is determined directly by the length of the path to the source.

How the angle between Sun and target could be updated automatically?

- 1. In neuroscience approach identifying brain as a computer this information would be stored by computation. Deep learning algorithms would be proposed by AI people. Standard physics mechanism for storing the information about the direction angles are proposed. Foraging bee would utilize solar compass. The information about directions in plane of Earth would be stored by using the information coming the polarization of the sunlight.
- Automatic updating of the direction S of Sun and the direction L of the food source relative to it should be understood. This requires computation and learning in neuroscience approach. I do not know enough about deep learning to articulate precisely why I do not believe this option.

A more radical option is that MB of bee stores this information into its own geometry? The proposal has been that MB explains the third person perspective of consciousness: this would explain also OBEs [K104, K127]. Could the MB provide a representation for the dynamics of the bee and its environment including the Sun? If MB contains flux tube S in the direction of Sun defining a pointer of sundial so to say, a temporary flux tube L in the direction of food source, and a temporary flux tube H along projection of L parallel to Earth, this is guaranteed and updating takes place automatically.

3. How the temporary flux tubes would generated? In TGD inspired theory of consciousness flux tubes serve as a correlate for attention. Dancer has directed its attention to the food source and has become connected by flux tube it. Could this bond be preserved so that the bee would be connected by flux tubes to the target? To be precise, these temporary flux tubes would be actually by pairs of flux tubes generated as flux tube loops from bee and food

source reconnect. One could also imagine kind of miniature variant of this representation if this sounds too non-local.

4. The flux tubes S in the direction of Sun would be naturally gravitational flux tubes possibly carrying dark matter with $h_{eff} = h_{gr}$. The mass M appearing in h_{gr} could be some fraction of solar mass. The angle between L and H a would code the information needed to realize the V shape. Same would apply to the gravitational flux tubes E of Earth. Earlier work suggests that a fraction 10^{-4} of Earths mass of the gravitational flux of Earth is at dark flux tubes $h_{eff} = h_{gr}$.

These flux tubes would provide a cognitive representation for the direction S of Sun, for the line L connecting the hive to the food source, and for the projection H of L along the surface of Earth. The MB of bee should have also gravitational flux tubes of Earth and since they are orthogonal to H: could these two kinds of gravitational flux tubes make possible the representation of H as edge of V? H and L would be behave like rigid body whereas Swould be like a pointer of sundial.

5. Does the rotation of the reference direction from L to E mean rigid body rotation for the MB (and body) of the dancer? Do solar flux tubes become flux tubes inside the vertical flux tubes? If so, the first part of waggle run would take place along the flux tube to target along H turned by $\pi/2 - \theta$. The second part of waggle run would take place along its mirror image with respect to rotated L.

Consider now the role of $h_{eff}/h = n$ having two widely different ranges of values.

1. The cyclotron energies of p and Ca^{2+} are extremely small for the ordinary value of Planck constant. This was one of the reasons motivating to the introduction of the hierarchy of Planck constants $h_{eff}/h = n$ [K55, ?]. The hypothesis $h_{eff} = h_{gr}$ implies that the cyclotron energies do not depend on the mass m of the particle and are in the range of energies of bio-photons (visible and UV). Also the gravitational Compton lengths of particles are independent of m. Also this encourages the consideration of the possibility that the MB of bee has flux tubes carrying gravitational flux tubes from Sun. The values are roughly of the order of 10^{14} if EEG photons have energies in visible and UV.

The directions of gravitational flux tubes to Sun and Earth define two preferred stationary directions. It seems natural to assign to them gravitational Planck constants $h_{E,qr}$ and $h_{S,qr}$.

2. Relatively small values of n are assignable to electrons of valence bonds and of aromatic cycles [L70]. $n < n_{max} = 100$ is a rough estimate. Thus they are much smaller than the values of $n = h_{gr}/h$ assignable to dark protons at magnetic flux tubes of say hydrogen bonds and assignable to gravitational fields. The model for valence bonds based on TGD predicts that n increases along the row of the periodic table and the molecules appearing as nutrients have the highest values of n associated with their valence bonds.

 $h_{eff}/h = n$ serves as a kind of measure for IQ of the system. More precisely, the recent interpretation is that n expresses the ability of the system to generate negentropy. I have proposed that chemical senses might detect the value of n. For instance, the higher the value of n, the more pleasant the odour. Aromatic compounds with aromatic cycles would have dark electrons at the flux tubes assignable to the cycles and therefore would have value of n larger than the usual.

Could the average value $\langle n \rangle$ measure the quality of the nectar? Could the dancer communicate the value of $\langle n \rangle$. Could be be more excited if the average value of n is large. This should be reflected in the value of f_w via the value of B_{end} if f_w really measures how excited the bee is.

15.4.4 Concrete model for the coding of the information about waggle dance at MB

Magnetic flux tubes forming part of MB serve as controllers of BB in TGD inspired quantum biology. This suggests that it could be possible to build a concrete model for the control of waggle dance in terms of magnetic flux tubes.

- 1. The simplest flux tubes are infinitely thin and thus their orbits have 2-D M^4 projection. I call them cosmic strings. They are space-time surface of form $X^4 = X^2 \times S^2 \subset M^4 \times CP_2$, where X^2 is minimal surface string world sheet and S^2 is geodesic sphere of CP_2 . CP_2 has two non-equivalent geodesic spheres. The first one has vanishing induced Kähler form and second is homologically non-trivial (non-contractible) and carries Kähler magnetic flux.
- 2. One has also more general preferred extremals $X^2 \times Y^2$, where Y^2 is complex sub-manifold of CP_2 obtained by replacing S^2 with a sphere with $g \ge 0$ handles.
- 3. One can deform these extremals in M^4 directions to get magnetic flux tubes, which are key players in TGD inspired quantum biology.

All geodesic circles of $Y^2 = S^2$ give rise to X with D(X) = 1 but the space-time projection is space-like and corresponds to single point in X^2 . How could one get time-like X as a projection of $U(1) \times U(1)$ orbits? The idea comes from the dynamics of rigid body generalized to that for the complex surface $Y^2 \subset CP_2$.

- 1. Think Y^2 as a rigid body in CP_2 and "kick" it into a rotational motion. This extremely simple motion might produce a preferred extremal. The idea can be illustrated for a geodesic circle S^1 of ordinary sphere. One can "kick" S^1 to a rotational motion around any axis defined by a line from origin to a point of S^2 . This motion describes geodesic circle as the image of a Cartan group $SO(2) \subset SO(3)$.
- 2. For infinitely thin flux tubes the space-time is effectively the string world sheet $X^2 \subset M^4$. X should define surface at X^2 . For a rotating Y^2 the orientation of Y^2 in CP_2 depends on the time coordinate t of X^2 . One would have a geodesic motion corresponding to $U(1) \subset U(1) \times U(1) \subset SU(3)$.
- 3. One can also imagine the dependence of the orientation of Y^2 on the space-like coordinate x of Y^2 : there would be "rotation" also in the x direction! The orientation of rotating Y^2 would depend on two string coordinates. Given $(t, x) \in X^2$ would correspond to a point $(\Phi, \Psi) \in U(1) \times U(1)$ and string world sheet itself to $U(1) \times U(1) \in F$! String world sheet would represent flag manifold qualia.
- 4. This picture is not yet realistic enough. One must have magnetic flux tubes with M^4 projection, which is not infinitely thin. They are obtained for the deformations $X^2 \times S^2$ solutions in M^4 directions increasing the dimension of M^4 -projection so that it is 4-D. $D(X) \ge 1$ is however needed to explain honeybee dance.
- 5. Also for the realistic flux tubes one obtains the rotation by allowing rotation in the additional two directions. A reasonable first guess is that the rotation is everywhere in fixed $U(1) \times U(1)$: this would correspond to a global choice of quantization axes for color quantum numbers.

Can one identify unique string world sheet X^2 now? What I call fermionic string world sheets are fundamental in TGD. They connect the orbits of partonic 2-surfaces carrying fermion numbers at their ends are indeed realized at the orbits of magnetic flux tubes. This brings in mind strong form of holography (SH) implied by strong form of general coordinate invariance in TGD. Maybe honeybee dance is in certain sense a holographic representation?

6. The temporal size scale T of X would correspond to the duration of the dance and would thus code for the distance to the food source. Hence T must be more or less equivalent with the parameter α of Shipman. The electromagnetic charge Q generated during the flight of forager correlates also with the distance (1 second corresponds to 1 km) and also corresponds to T.

T would naturally correspond to a finite size scale for CD assignable to the conscious self assignable to the honeybee dance.

7. It is quite possible that the full symmetry breaks down, and the intersection with X^4 gives only single geodesic in the torus $U(1) \times U(1)$. It is characterized by winding numbers (m, n). Waggle run involves two important frequencies: vibration frequency f_v of wings and waggle frequency f_w : these frequencies could correspond to the two conserved Hamiltonians assigning two-momentum to the waggle orbit. These momenta would be equivalent with frequencies. If (f_w, f_v) corresponds to the pair (f_1, f_2) of rotation frequencies at torus $U(1) \times U(1)$ for the rigid body motion one would have $m/n = 20 = f_v/f_w$. The same frequency ratio appears in the system of plastic balls exhibiting life like properties [L71]. Could the dynamics of preferred extremals favor this value of m/n and give Ca^{2+} its unique role in biology and neuroscience?

15.4.5 Summary

The basic vision behind TGD view is that flag manifold coordinates represent geometric qualia and honeybee dance represents them. The choice of the subgroup $U(1) \times U(1)$ representing point of flag manifold is represented at space-time level. In TGD framework geodesic dynamics coupled to Kähler force is the physically attractive first guess since it would be 1-D idealization of the dynamics of classical TGD, which is obtained from this dynamics by replacing point-like particle with 3-surfaces. This dynamics follows from the twistor lift of TGD by dimensional reduction occurring dynamically. At the point-like limit it gives geodesic motion coupled to Kähler force and allowing SU(3) charges as conserved charged. If one requires that also action $\int j \cdot A$ is invariant the symmetries reduce to $U(1) \times U(1)$ characterizing particular choice of Kähler function of CP_2 (it does not depend on coordinates (Φ, Ψ) assignable to $U(1) \times U(1)$).

The classical dynamics of TGD could explain how the map from the dual of $u(1) \times u(1)$ algebra to the space-time level - the behive - is realized.

1. The orbits for completely integrable systems are parameterized by the conditions that maximal number of commuting Hamiltonians are constant. TGD is integrable theory and what suggests itself is that the Hamiltonians (P_{Φ}, P_{Ψ}) assignable to the phase angle coordinates (Φ, Ψ) parameterizing $U(1) \times U(1)$ orbit in CP_2 are constants at the projection X of the $U(1) \times U(1)$ orbit to X^4 the dimension D(X) satisfies $D(X) \leq 2$. For D(X) > 0 the representation is dynamica.

Space-time sheet could allows D(X) > 0 only for very few values of the momentum (P_1, P_2) : the projections of other points of F would be discrete. One parameter subgroup of $U(1) \times (1)$ (torus orbit) would define the line H and its mirror image along magnetic flux tube. The edges of V would be obtained by π rotation from each other.

Waggle run would correspond to time-like line and its spatial projection would represent the orientation angles (θ, ϕ) of the food source as those associated with with the diagonal of V. The temporal size T of X would determine the duration of waggle run and therefore the distance to the source. The electromagnetic charge Q generated to the abdomen of the bee during the flight is proportional to T of the waggle run and codes for the length of the path.

2. The natural parameterization of the situation is in terms of Darboux coordinates for CP_2 for which Kähler potential is given by $A = P_k dQ^k$. Using standard complex coordinates ξ_i for CP_2 [L2], one can choose Q_i to be phase angles of ξ^i : $Q_1 = \Phi$, $Q_2 = \Psi$. These coordinates are cyclic coordinates not appearing in Kähler function of CP_2 and they correspond to $U(1) \times$ U(1) isometries of CP_2 . They are constants of motion also for the geodesic dynamics coupled to Kähler form. Conservation laws would correspond to the constancy of the corresponding Hamiltonians P_i . The orbit at X (or equal to it) would be therefore surfaces $P_i = constant$.

The ratio $v = P_1/P_2$ would define the velocity $v = d\Psi/d\Phi$. The interpretation of P_i as frequencies is natural - hence the notation $P_i = \omega_i$ is more appropriate and an interesting possibility is that these frequencies could serve as a measure for the eagerness of the bee. An interesting possibility is that the frequencies f_v and f_w correspond to f_i . This would give $v \simeq 1/20$.

X is intersection of HY with X^4 . In so called Chladni mechanism [L46] for which selforganization patterns for charged particles correspond to the nodes of electromagnetic field so that the force vanishes. The situation would be exactly the same now but em field would be replaced by the induced Kähler form.

- 3. This picture would allow to understand why the two waggle runs become parallel at large distances and why they form V shape at smaller distances. Also the criticality could be understood. At criticality the second branch of V would become vertical and the geometry of the dance orbit would change so that waggle periods would be parallel to Earth and at opposite sides of the circle to code the information about the direction of the food source.
- 4. The waggle pattern characterized by the frequency f_w represents information related to the dynamics in M^4 degrees of freedom allowing perhaps only very limited number of continuous orbits. Also vibrational frequency f_v would represent additional information. The interpretation as cyclotron frequencies for Ca^{2+} and proton makes sense. These frequencies could correspond to the conserved momenta or equivalently frequencies associated with Ψ and Φ .
- 5. The rotation of the frame defined by the direction of Sun to that defined by the direction of local gravitation would correspond to a rotation of the MB of the bee. Here the permanent dark gravitational flux tubes would play a key role in defining the frame.

Needless to say, the proposed representation is very general and perhaps provide a universal manner to represent geometric information. Flag manifold qualia might be universal manner to represent geometric information. In the case of M^4 twistor lift forces to introduce the geometric variant of twistor space as $M^4 \times CP_2$ and also generalization of Kähler structure and symplectic structure. Now the counterpart of $U(1) \times U(1)$ consists of time translations and translations in some spatial direction and point of the twistor space correspond to a choice of time axis (energy quantization axis) and quantization axes of spin.

Acknowledgements: The impulse for taking a fresh look at quantum honeybees came from Johan Frisch who asked references to the work of Shipman: thanks to Johan! I am also grateful for Jerry Decker for digging references to the work of Shipman from web.

Chapter 16

A Model for Protein Folding and Bio-catalysis

16.1 Introduction

The model for the evolution of the genetic code leads [?] to the idea that the folding of proteins obeys a code inherited from the genetic code. One can imagine several variants of this code. One of them is that amino-acid behaves like the conjugate Y_c of the middle nucleotide of the codon XYZ coding for it. Conjugation for amino-acids would correspond to the hydrophilic-hydrophobic dichotomy. Also catalyst action could reduce to effective base pairing in this picture chemically and at the level of quarks associated with the flux tube to matter antimatter conjugation. The guess that amino-acid and its conjugate form pairs turned out to be wrong however and after various twists and turns I ended up with the hypothesis that the amino-acid in protein behaves like Y_cZ_c where Z corresponds to third nucleotide for some codon coding for the amino-acid.

There exists a wonderful book "Proteins: Structures and Molecular Properties" by Thomas E. Creighton published 1993 [I130] and I am grateful for Timo Immonen for possibility to use the book. In the following I freely refer to the general facts discussed in this book rather than referring separately to every detail.

16.1.1 Flux Tubes As Correlates Of Directed Attention At Molecular Level

After some trials one ends up with a general conceptualization of the situation with the identification of ("wormhole") magnetic flux tubes as correlates for attention at molecular level so that a direct connection with TGD inspired theory of consciousness emerges at quantitative level. Whether wormhole flux tubes or ordinary flux tubes are needed is not a completely settled question yet and the attribute "wormhole" will not be used in the sequel. This suggests a generalization of the DNA as topological quantum computer paradigm making it much more detailed.

There are too many uncertainties involved to allow anything except playing with the options that one is able to imagine. There are two kinds of flux tubes. Those between amino-acids and those between amino-acids and water molecules. The contractions of flux tubes in \hbar changing phase transitions are expected to be important for protein folding and could also give rise to the interaction responsible for hydrophily and hydrophoby and be therefore highly relevant for protein folding. A basic question about which I became aware only about one year after working out the first draft of this chapter concerns the relative importance of these two kinds of flux tubes. The first model assumed that only amino-acid-amino-acid flux tubes are relevant and assumed strong selection rules inspired by DNA as TQC model. The second model which emerged year later represents an extreme in which only the flux tube connections between amino-acids and water molecules assumed to be responsible for hydrophily and hydrophoby induce the interactions between amino-acids as secondary interactions. This model works surprisingly well at qualitative level.

16.1.2 The Model Of Folding Code Based On Flux Tube Connections Between Amino-Acids

The first model assumes that only the flux tubes between amino-acids are relevant for protein folding.

What kind of atoms can be connected by flux tubes?

- 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 prerequisite for a hydrogen bond or as 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.

Color inheritance by a reconnection of flux tubes

- 1. There should exist some mechanism allowing amino-acids to inherit the base pairing property from the tRNAs associated with them so that one can identify amino-acid with the middle nucleotide of the codon coding it. If tRNA middle nucleotide is connected to O = of the amino-acid, this becomes possible since the reconnection of flux tubes preserves the "color" of the flux tubes coded by (A,T,G,C) that is by the quark or anti-quark coding for the nucleotide. The temporary formation of a hydrogen bond between N - H and O = of two amino-acids as in the case of alpha helix would allow N - H to inherit the conjugate of the color associated with O =. Alternative interpretation is that this hydrogen bond is possible only if the predetermined color of N - H is consistent with the inherited one. The inheritance of flux tube color would be a completely general mechanism and even the donor atoms in the residues of amino-acids could inherit the color of O = in this way.
- 2. A possible interpretation for the fixing of the flux tube color is in terms of quantum measurement selecting one color from quantum superposition in the reconnection process. This would mean that the unitary process can bring superposition back and reconnection process can change the inherited color. The hydrogen bonds between water molecules could correspond to quantum superpositions of different colors. This superposition property might relate to the wobble base pairing phenomenon for the third nucleotide in tRNA.

Folding code

The identification of N - H as a representation for the conjugate of the third nucleotide Z means that amino-acids would remember which codon coded them. If only hydrogen bond like flux tubes are allowed, flux tubes can connect only amino-acids satisfying $Y = Z_c$. If = O - O = flux tubes are allowed Y = Z rule favored by the model of DNA as topological quantum computer follows. The isospin symmetry of the third nucleotide implies that both rules are quite flexible. If one identifies hydrogen bond with flux tube (Y(n) = Z(n + k)) the model works badly for both options. If one assumes only that the presence of a flux tube connecting amino-acids in either direction (Y(n) = Z(n + k) or Z(n) = Y(n + k)) is a prerequisite for the formation of hydrogen bond, the model works. Y = Z rule is favored by the study of five enzymes: the possible average length of alpha helix is considerably longer than the average length of alpha helix if gene is the unique gene allowing to satisfy Y = Z rule. The explicit study of alpha helices and beta sheets for these enzymes demonstrates that the failure to satisfy the condition for the existence of hydrogen bond fails rarely and at most for two amino-acids (for 2 amino-acids in single case only).

Y = Z rule could mean a solution of the basic problem of proteonics: Do genes determine the folding of proteins and how this would take place? The interpretation would be that the information loss suggested by the many-to-one character of the genetic code is only apparent. The apparently lost information which corresponds to the A - G and T - C symmetries of the third nucleotide codes for the hydrogen bonding and hence for the folding of the protein. The model in its most stringent form is easy to kill since in the case of alpha helices and beta sheets the hydrogen bonding fixes completely the DNA sequence coding for the protein. A weaker variant of the model based on quantum variant of wobble base pairing: in this case there are no conditions on DNA sequence. It turns out that only this variant works. Hence hydrogen bonded amino-acid behave as if they were coded by the unique codon consistent with Y = Z rule.

Quantitative model

The quantitative model relies on the assumption that the contribution of a flux tube connecting two amino-acids to the potential energy depends only on the distance between the molecules in question. The extremals of the total interaction energy are same for any choice of the potential and only the absolute minimum of the interaction energy depends on the choice of the potential. The simplest potential corresponds to harmonic oscillator potential and would explain formation of alpha helices and beta sheets and with the fact that hydrophilic and hydrophobic residues tend to have a large distance and only few flux tube contacts. For large Planck constant also long flux tubes could correspond to attractive harmonic oscillator potential. Also the contribution of other interactions between neighboring amino-acids are expected to be present but are neglected in the simplest model. The model predicts alpha helices and beta sheets, and more generally, periodic structures, as solutions to energy minimization equations.

16.1.3 A Model For Protein Folding Based On Flux Tubes Between Amino-Acids And Water Molecules

This proposal represents a diametrical opposite of the first model in the sense in that it assumes flux tube connections only between amino-acids and water molecules. These flux tubes mediate an attractive (repulsive) interaction in the case of hydrophily (hydrophoby) due to the behavior of magnetic (presumably) interaction energy as a function of Planck constant (or integers characterizing the level of dark matter) assignable to the flux tube. For hydrophoby (hydrophily) the interaction energy is minimized for long (short) flux tubes. The interaction between amino-acids is induced by this interaction in a way analogous to how the interaction between electrons and ions induces secondary interaction between the members of a Cooper pair. The model explains the basic qualitative aspects of protein folding and the quantitative model of folding based on amino-acid-amino-acid flux tubes allows a generalization which is however discussed at numerical level.

16.1.4 Protein folding, hydrophoby and hydrophily, and molecular attention

The third proposal asks whether protein folding could be induced by the flux tube connections of protein with water's MB rather than between proteins as in the first two models. This model is certainly an idealization since S-S valence bonds are known to play an important part in the folding. These flux tube connections could be accompanied by hydrogen bonds - even longer than usual if h_{eff} as spectrum for water as has been proposed. This involves more detailed ideas

about the origin of hydrophobia and hydrophilia at the level of magnetic body (MB) discussed more quantitatively in [L104]. Hydrophilic amino acids would tend to form flux tube connections with the MB of water unlike hydrophobic amino acids. The formation of flux tube connection would serve as a correlate for attention at molecular level.

16.1.5 Postlude

The above summarized efforts are just the first attempts to apply TGD views in order to understand protein folding, and must be taken just as excercises without deeper vision about the meanings of protein folding and folding code assuming it exists.

Decade after writing this chapter the vision about the role of DNA in TGD Universe evolved with inspiration coming from the model of water memory and homeopathy and the realization that homeopathy might represent a core elemement in the functioning of immune system involving new physics in an essential way. The key idea is that dark variants of amino-acid sequences would have coded for the 2-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 antigene 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.

It would be fascinating if the vision about the role of flux tube connections would generalize to interactions of all molecules in living matter. The mere selection rules would mean hidden simplicity behind extremely complex looking interactions in living matter. The model for protein folding and catalytic action described in the original version of this chapter was the first attempt in this direction. At the end of the chapter an improvement of the model inspired by recent considerations is suggested.

Several persons have helped me in writing this chapter. I want to express my gratitude to Ulla Mattfolk for informing about the idea of protein folding code and to Dale Trenary for interesting discussions, for suggesting proteins which could allow to test the model, and for providing concrete help in loading data help from protein data bank. Also I want to thank Timo Immonen for discussions and for loaning the excellent book "Proteins: Structures and Molecular Properties" of Creighton. I am also grateful for Pekka Rapinoja for writing the program transforming protein data file to a form readable by MATLAB.

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 [L31].

16.2 A Model For Flux Tubes

Biochemistry represents extremely complex and refined choreography. It is hard to believe that this reduces to a mere unconscious and actually apparent fight for chemical survival. In TGD Universe consciousness would be involved even at the molecular level and magnetic body would be the choreographer whose dance would induce the molecular activities. This picture combined with the idea of standard plugs and terminals at which flux tubes end, leads to a to a picture allowing to formulate a model for protein folding.

16.2.1 Flux Tubes As A Correlates For Directed Attention

Molecular survival is the standard candidate for the fundamental variational principle motivating the molecular intentional actions. There is entire hierarchy of selves and the survival at the higher level of hierarchy would force co-operation and altruistic behavior at the lower levels. One might hope that this hypothesis reduces to Negentropy Maximization Principle [K80], which states that the information contents of conscious experience is maximized. If this picture is accepted, the evolution of molecular system becomes analogous to the evolution of a society. Directed attention is the basic aspect of consciousness and the natural guess would be that directed attention corresponds to the formation of magnetic flux tubes between subject and target. The directedness property requires some manner to order the subject and target.

- 1. The ordering by the values of Planck constant is what first comes in mind. The larger spacetime sheet characterized by a larger value of Planck constant and thus at a higher level of evolutionary hierarchy would direct its attention to the smaller one.
- 2. Also the ordering by the value of p-adic prime characterizing the size scale of the space-time sheet could be considered but in this case directedness could be questioned.
- 3. Attention can be directed also to thoughts. Could this mean that attention is directed from real space-time sheets to p-adic space-time sheets for various values of primes but not vice versa? Or could the direction be just the opposite at least in the intentional action transforming p-adic space-time sheet to real space-time sheet? Perhaps directions are opposite for cognition.

The generation of (wormhole) magnetic flux tubes could be the correlate for the directed attention, not only at molecular level, but quite generally. Metaphorically, the strands of braid would be the light rays from the eyes of the perceiver to the target and their braiding would code the motions of the target to a topological quantum computation like activity and form a memory representation at least. The additional aspect of directed attention would be the coloring of the braid strands, kind of coloring for the virtual light rays emerging from the eyes of the molecular observer. In the case of DNA this can induce a coloring of braid strands emerging from amino-acids and other molecules so that it would indeed become possible to assign to free amino-acid the conjugate of the codon XYZ coding for it.

Attention can be also redirected. For this process there is a very nice topological description as a reconnection of flux tubes. What happens is that flux tubes $A \to B$ and $C \to D$ fuse for a moment and become flux tubes $A \to D$ and $C \to B$. This process is possible only if the strands have the same color so that the values of the quark charges associated with A and B are the same.

- 1. Reconnection process can modify TQC programs. For instance, in the case of the flux tubes coming from nucleotides X and X_c and ending to the lipid layer this process means that X and X_c and corresponding lipids become connected and genome builds memory representation about this process via similar link.
- 2. Reconnection process makes also possible what might be called color inheritance allowing amino-acids to inherit the conjugate colors of the nucleotides of the codon coding it.
- 3. DNA would have memory representation about molecular processes via these changing braiding topologies, and one could say that these molecular processes reflect the bodily motions of the magnetic body. Entire molecular dynamics of the organism could represent an enormous TQC induced by the motor activities of the magnetic body. At the level of sensory experience similar idea has been discussed earlier [K127]: out of body experiences (OBEs) and illusions such as train illusion could be understood in terms of motor action of magnetic body inducing virtual sensory percepts.

Attention can be also switched on and off. Here the structure of the lipid ends containing two nearby situated = O: s suggest the mechanism: the short flux tube connecting = O: s disappears by reconnection mechanism with a pair of hydrogen bonded water molecules leading to a shortcut of the connecting flux tubes to = $O - -H_2O$ hydrogen bonds. The minimization of Coulomb interaction energy at each end implies that re-appearance of the flux tubes creates a short flux tube with the original strand color.

16.2.2 Does Directed Attention Generate Memory Representations And TQC Like Processes

Directed attention induces braiding if the target is moving and changing its shape. This gives rise to a memory representation of the behavior of the object of attention and also to a TQC like process. A considerable generalization of TQC paradigm suggests itself. Tqc could be induced by the braiding between DNA and lipids, DNA and proteins via folding processes, DNA RNA braiding and braiding between DNA and its conjugate, DNA and protein braiding. The outcome of TQC would be represented as the temporal patterns of biochemical concentrations and rates and there would be hierarchy of p-adic time scales and those associated with the dark matter hierarchy.

For instance, the protein content of lipid membranes is about 50 per cent and varies between 25-75 per cent so that protein folding and lipid flow could define TQC programs as self-organization patterns. The folding of protein is dynamical process: alpha helices are created and disappear in time scale of 10^{-7} seconds and the side chains of protein can rotate.

The details of the TQC like process depend on what one assumes. The minimal scenario is deduced from the transcription and translation processes and from the condition that magnetic body keeps control or at least keeps book about what happens using genome as a tool. The picture would be essentially what one might obtain by applying a rough model for web in terms of nodes and links. The reader is encouraged to use paper and pencil to make the following description more illustrative.

- 1. Assume that mRNA and DNA remain connected by flux tubes after transcription and that only reconnection process can cut this connection so that mRNA inherits the conjugate colors of DNA. Assume same for mRNA and tRNA. Assume that amino-acid associated with tRNA has similar flux tube connections with the nucleotides of tRNA. Under these assumptions amino-acid inherits the conjugate colors of DNA nucleotides via the connection line DNAmRNA-tRNA-amino-acid faith-fully if all links are correspond to quark pairs rather than their superpositions. Wobble pairing for Z nucleotide could actually correspond to this kind of superposition.
- 2. One can consider several options for the amino-acid-acid DNA correspondence but trial-anderror work showed that a realistic folding code is obtained only if X, Y, and Z correspond to O - H, O =, and NH_2 in the constant part of free amino-acid. During translation the formation of the peptide bond between amino-acids dehydration leads to a loss of O - H and one H from NH_2 . The flux tube from tRNA to O - H becomes a flux tube to water molecule inheriting the color of X so that $O = -NH_2$ of the amino-acid inside protein represents the conjugate of YZ.
- 3. Hydrogen bonding between O = and NH of n: th and n + k: th amino-acids inside alpha helices and n: th and n + 1: th amino-acids inside beta strands reduces effectively to base pairing characterized by Y = Z rule. Assuming that flux tube is only a prerequisite for the formation of hydrogen bond, Y(n) = Z(n + k) or Z(n) = Y(n + k) allows the existence of hydrogen bond. The identification of hydrogen bond with flux tube gives a more stringent condition Y(n) = Z(n+k). The first option is favored. Either condition is extremely restrictive condition on the gene coding the amino-acid unless one assumes quantum counterpart of wobble base pairing for mRNA or tRNA-amino-acid pairing in the case of Z nucleotide (as one indeed must do). Note that the O = atom of the amino-acid is in a special role in that it can have hydrogen bond flux tubes to donors and flux tube connections with O =: s of other amino-acids, the residues of amino-acids containing acceptors (say O = or aromatic ring), and with the aromatic rings of say ATP.
- 4. The recombination process for two conjugate DNA-mRNA-tRNA-amino-acid links can transform the flux tubes in such manner that one obtains link between the = O: s of amino-acids A_1 and A_2 characterized by Y and Y_c . Besides hydrogen bonding this mechanism could be central in the enzyme substrate interaction. The process would pair tRNAs corresponding to Y and Y_c together to give DNA-mRNA-tRNA-tRNA-mRNA-DNA link providing a memory representation about amino-acid pairing $A_1 A_2$. One could say that magnetic body creates with the mediation of the genome dynamical TQC programs to which much of the bio-molecular activity reduces. Not all however, since two amino-acid pairs $A_1 A_2$ and $A_3 A_4$ can recombine to $A_1 A_4$ and $A_3 A_2$ without DNA knowing anything about it. Magnetic body would however know.
- 5. The constant part of non-hydrogen bonded amino-acid inside protein would behave like $Y_c Z_c$ if amino-acid is coded by XYZ. The COOH end of protein would behave like $X_c Y_c Z_c$.

Also flux tubes connecting the residue groups become possible and protein does not behave like single nucleotide anymore. By color inheritance everything resulting in the reconnection process between O = and NH_2 and residues reduces in a well-defined sense to the genetic code.

16.2.3 Realization Of Flux Tubes

The basic questions about flux are following. Where do they begin, where do they end, and do they have intermediate plugs which allow temporary cutting of the flux tube.

Where do flux tubes begin from?

The view about magnetic body as a controller of biological body using genome as a control tool suggests that DNA is to a high degree responsible for directed attention and other molecules as targets so that flux tubes emanate from DNA nucleotides. The reason would be that the aromatic cycles of DNA correspond to larger value of Planck constant. Some chemical or geometric property of DNA nucleotides or of DNA nucleotides of DNA strand could raise them to the role of subject. Aromatic cycle property correlates with the symmetries associated with large value of Planck constant and is the best candidate for this property.

If this picture is accepted then also some amino-acid residues might act as subjects/objects depending on the option. Phe, His, Trp, Tyr contain aromatic cycle. The derivatives of Trp and Tyr act as neurotransmitters and His is extremely effective nucleophilic catalyst. This would make possible more specific catalytic mechanisms through the pairing of Phe, His, Trp, and Tyr with residues having flux tube terminals.

This raises the question about the physical interaction determining the color of the strand emerging from the aromatic cycle. The interaction energy of quark at the end of flux tube with the classical electromagnetic fields of nuclei and electrons of the ring should determine this. The wormhole contact containing quark/antiquark at the throat at space-time sheet containing nuclei and electrons could also de-localize inside the ring. One of the earliest hypothesis of TGD inspired model for living matter was that wormhole Bose-Einstein condensates could be crucial for understanding of the behavior of biomolecules [K147]. Wormhole throats with quark and antiquark at their throats appear also in the model of high T_c superconductivity [K26]. As far as couplings are considered, these wormhole contacts are in many respects analogous to the so called axions predicted by some theories of elementary particle physics. The wormhole contact like property is by no means exceptional: all gauge bosons correspond to wormhole contacts in TGD Universe.

The only manner for the electronic space-time sheet to feed its electromagnetic gauge flux to larger space-time sheets using exactly two wormhole contacts is to use wormhole contacts with \overline{u} and d at their "upper" throat (T, G). For proton one would have \overline{d} and u at their "upper" throat (A, C). The presence of electron or proton at nucleotide space-time sheet near the end of flux tube might allow to understand the correlation. The transfer of electrons and protons between spacetime sheets with different p-adic length scale is basic element of TGD based model of metabolism so that there might be some relation.

Acceptors as plugs and donors as terminals of flux tubes?

Standardization constraint suggests that flux tubes are attached to standard plugs and terminals. The explicit study of various biological molecules and the role of water in biology gives some hints.

- 1. An attractive idea is that = O serves as a plug to which flux arrives and from which it can also continue. For the minimal option suggested by hydrogen bonding O = could be connected to two donors and O = could not be connected to O =. The assumption that the flux tube can connect also two O =: s represents a hypothesis going outside the framework of standard physics. A stronger assumption is that all acceptors can act as plugs. For instance, the aromatic rings of DNA nucleotides could act as acceptors and be connected to a sequence of O = plugs eventually terminating to a hydrogen bond.
- 2. Donors such as O H would in turn correspond to a terminal at which flux tube can end. One might be very naïve and say that conscious bio-molecules have learned the fundamental

role of oxygen and water in the metabolism and become very attentive to the presence of = O and O - H. = O appears in COOH part of each amino-acid so that this part defines the standard plug. = O appears also in the residues of Asp, Glu, Asn, Gln. O - H groups appear inside the residues of Asp, Glu and Ser, Thr.

- 3. Hydrogen bonds X H -Y have the basic defining property associated with directed attention, namely the asymmetry between donor X and acceptor Y. Hence there is a great temptation consider the possibility that hydrogen bonds correspond to short flux tubes, that flux tubes could be seen as generalized hydrogen bonds. Quite generally, Y could be seen as the object of directed attention of X characterized by larger value of Planck constant. The assumption that two O =: s, or even two acceptors of a hydrogen bond, can be connected by a flux tube means more than a generalization of hydrogen bond the connection with a donor would correspond only to the final step in the sequence of flux tubes and plugs giving rise to a directed attention.
- 4. This hypothesis makes the model rather predictive. For instance, N H, NH_2 , O H and much less often C H and S H are the basic donors in the case of proteins whereas O =, -O-, -N = S S, $-S^-$ and aromatic rings are the basic acceptors. Reconnection process should be involved with the dynamics of ordinary hydrogen bonding. Reconnection process implies inheritance of the flux tube color and means a realization of the symbol based dynamics. It turns out that this hypothesis leads to a model explaining basic qualitative facts about protein folding.

16.2.4 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 [I20]. 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.

Let us denote by $= O_1$ and $= O_2$ the two oxygens (maybe analogs of right and left hemispheres!) in question. 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.

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 =: s form 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 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 $= O_2$ can be understood as being due to the minimization of Coulomb interaction energy.

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 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. Phosphorylation would be an absolutely essential for both metabolism and buildup of connection lines acting as braid strands. 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.

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 [K103]: 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.

16.2.5 Introns And DNA-Protein Attachment

An example is the situation in which protein acts as an enzyme attaching on DNA. Suppose that this process effectively reduces to a base pairing between amino-acid and DNA nucleotide. Protein can attach to any portion of DNA. The simplest interaction is the attachment to the gene coding for the amino-acid itself but much more general enzymatic interactions are possible. It must be however noticed that DNA sequence coding for given amino-acid sequences is considerably longer than amino-acid sequence: the sequence coding for 10 amino-acids is about 10 nm long whereas the corresponding straight amino-acid strand is about 4.7 nm long. It is known that DNA can change its conformation from strand during enzyme-DNA action [I130], and the contraction of DNA strand might make possible to have enzyme-DNA interaction involving fusion along several subsequent amino-acids. This kind of mechanism might work also in the case that attachment region corresponds to several exons. There is however no need to assume that subsequent aminoacids are form a contact with DNA.

One can of course ask whether genes containing introns tend to code for proteins which are used for topological quantum computations. Introns, perhaps the repeating sequences with no obvious function, would have at least this useful function but very probably much more useful ones too (they are now known to be transcribed to RNA and TGD suggest that language corresponds to intronic gene expression). The emergence of introns might be somewhat like the emergence of information society.

The folding of proteins tends to be conserved in the evolution whereas primary structure can change quite a lot apart from some amino-acids critical for enzymatic action. This confirms with the effective base pairing interaction between amino-acids and DNA to be discussed later and would mean that DNA-amino-acid TQC programs are rather robust against mutations.

16.3 Model For The Folding Code Based On Interactions Mediated By Flux Tubes Between Amino-acids

The model for the protein folding to be discussed in this section relies on the hypothesis that dark flux tube connections between amino-acids and their contractions in \hbar changing phase transitions

determine the dynamics of the folding. A model in which flux tubes between amino-acids and water molecules alone induce the interactions between amino-acids will be discussed in separate section. A realistic model might involve both kind of flux tubes.

16.3.1 4-D Spin Glass Energy Landscape And Code Of Catalytic Action

There is a proposal that protein folding corresponds to a motion in a fractal spin glass energy landscape in presence of external perturbations due to the presence of water and leading to the bottom of some deep valley [I102, I102]. In TGD framework 3-D spin glass landscape is replaced by 4-D one [K108]. The vacuum degeneracy of Kähler action implies 4-D spin glass energy landscape in the sense that quantum jump sequences lead to space-time sheets representing asymptotic self organization patterns depending only weakly on the initial conditions (with respect to subjective time measured as quantum jumps). Proteins would be like skilled musicians possessing a repertoire of motor activities represented by deep valleys in 4-D spin glass landscape.

This picture generalizes to the functioning of living matter in various scales and the quantum dynamics of brain is a natural application giving also connection with p-adicity since ultra-metric topology is naturally associated with the space of valley bottoms. In the case of catalytic reactions a quantum jump changing Planck constant for some magnetic flux tubes connecting some living biomolecules (DNA, RNA, amino-acids, water(?), ..) and changing the lengths of these flux tubes could be the basic mechanism leading from a given valley to a new one and the reduction of the genetic code to single nucleotide or di-nucleotide code would code this quantum jumps.

To me this proposal for the folding code - or rather, the code of entire biocatalysis - looks so beautiful that it deserves to be killed this should be easy for a professional biochemist. If the hypothesis survives, it would provide a royal road to the understanding of the catalytic biochemistry.

16.3.2 Flux Tubes And Amino-Acids

Matter antimatter asymmetry at the level of interactions of amino-acids

The first thing that I learned was that in the case of amino-acid belonging to protein interior second nucleotide Y in the codon XYZ coding for amino-acid is what matters. Only Y = A, G amino-acid residue can form hydrogen bonds and is hydrophilic and thus interacts strongly with water and DNA and RNA. In T, C case the formation of hydrogen bonds is impossible or rare (ser, thr). In their interactions with water these amino-acids are passive, or rather-avoid water-and tend to interact with each other. This division is fundamental for the understanding of the interactions of amino-acids. The division of amino-acids to hydrophobic *resp.* non-hydrophobic ones corresponds to the assignment of quarks to A and G and antiquarks to T and C so that strong matter antimatter asymmetry is in question. Similar asymmetry appears in cosmology: in TGD Universe antimatter resides inside cosmic strings in the interior of big voids containing matter as galaxies at their boundaries so that one can understand why antimatter is not visible.

Flux tubes can connect with all electronegative atoms

The model for di-nucleotide precursor code [?] involves precursors for which 3 precursors contain only oxygen ions or double bonded oxygens. The only possible conclusion is that oxygen can connect to any DNA letter (quark or antiquark) and that first letter-precursor correlation is a selection of the most probable alternative. Also in water oxygen atoms should form flux tube contacts with each other and amino-acids and DNA. Also nitrogen atoms might form similar flux tube connections and this was assumed in the model. Same would apply to sulphur appearing in met and tyr and to electronegative atoms in general.

What can one learn from the formation of alpha helices and beta sheets?

Assume that hydrogen bonds correspond to flux tubes. The formation of peptide bonds by the elimination of H_2O -molecules and generation of hydrogen bonds between N - H and O = is an essential step in the formation of alpha helices and beta sheets. Second observation is that free amino-acids decompose naturally into three parts corresponding to O = COH, R, and NH_2 . One
can also count O = as a separate unit so that there would be four units in this case. This suggests that amino-acid could correspond to the entire DNA codon XYZ coding for it. In this case there would be 2 flux tubes per amino-acid and one can consider the following options.

- 1. Y could correspond to either R or O =. If hydrogen bonds correspond to flux tubes, R Y correspondence is not realistic. The reason is that R should be either donor or accept and hydrophobic amino-acids do not possess neither property. Hence only O = can correspond to Y.
- 2. O H could correspond to Z, O = to Y, and NH_2 to X. For this option the amino-acid in protein would correspond to XY. If one identifies hydrogen bonds as special case of flux tubes, the hydrogen bonds of alpha helix would obey $X Y_c$ rule which seems too restrictive.
- 3. O-H could correspond to X, R or O = to Y, and NH_2 to Z. For this option the amino-acid in protein would correspond to YZ. In this case the hydrogen bond of alpha helix would obey $Y = Z_c$ rule which by the isospin symmetry of the last nucleotide of the codon might be flexible enough.

Interactions of proteins with ions and electrons

Proteins interact also with electrons and ions. Typical process are the addition or removal of proton, electron, ion such Ca⁺⁺, or molecule such as O_2 . These interactions are not well understood. For instance, the interactions involve the transfer of electrons between ligand protein and protein inducing oxidation (electron is given), reduction (electron is received) or redox reaction (both reduction and oxidation take place). In metabolism redox process is central. These reactions are reversible and it is difficult to understand how electrons are able make their long journey from the interior of the ligand so fast and avoiding dissipative effects. The formation of cyclotron Bose-Einstein condensates of bosonic ions and electronic Cooper pair condensates at the magnetic flux tubes connecting ligand and protein might provide the solution of the mystery. Note that the new nuclear physics predicted by TGD predicts nuclei which can have anomalous em charge associated with the color fluxtubes connecting nucleons to nuclear string so that fermionic ions Na^+, Cl^-, K^+ could have exotic bosonic counterparts.

16.3.3 Trying To Identify The Folding Code

The basic question is what kind of generalized pairings are realistic for amino-acids. The identification of hydrogen bonds as flux tubes leads to rather unique identification of the pairing and excludes the naïvely expected $Y - Y_c$ pairing.

A trial for the folding code

Protein folding code is something which is expected to exist but is not understood [I126]. This inspired a work which led to several trials for the folding code. Also a natural generalization to a code for catalysis emerged. In the most plausible candidate for the code flux tubes are identified as correlates of directed attention at molecular level. By their asymmetry hydrogen bonds are identified as a special case of flux tubes. Free amino-acid behaves like $X_c Y_c Z_c$ and the amino-acid inside protein like $Y_c Z_c$. There are two flux tubes per amino-acid corresponding to N - H and O = representing Z_c and Y_c .

This leaves two options for pairing.

- 1. If O = can act as a terminal for hydrogen bond and long flux tube then N H and Y can connect simultaneously to O = and one has Y = Z pairing.
- 2. If $O = \text{can act as a terminal for only single flux tube representing Y then reconnection process for <math>N H$ and $O = \text{flux tubes creates the hydrogen bond and } Y = Z_c$ pairing for amino-acids results

Both pairings are highly flexible so that obvious inconsistencies with the data about alpha helices and beta sheets are avoided. A highly non-trivial and testable prediction of both pairings

is that the two identical proteins coded by different DNA sequences can have different foldings since the allowed pairings are not identical. Thus amino-acids would remember at the level of the braidings which DNA sequence coded them. This prediction can be avoided only Z flux tube corresponds to a quantum superposition of the nucleotides coding for the amino-acid in question so that one has quantum superposition over quark pairs associated with the third nucleotide.

The two-point mutations possibly carried out intentionally by the magnetic body controlling the genome conserving amino-acid pairings by hydrogen bonds and thus perhaps also folding and the catalytic properties should transform $Y = Z_c$ (Y = Z) pair to an allowed pair of this kind so that quite wide repertoire of allowed 2-point mutations is available for this option.

$Y = Z_c$ or Y = Z pairing might work

The isospin symmetry of the third nucleotide implies that $Y = Z_c$ pairing is quite flexible. Roughly, the rule would allow flux tube connections only between amino-acids for which Y and Z correspond to quark and antiquark. The amino-acid pairs can be classified to three types. The amino-acid pairs for which both amino-acids can act as acceptors and donors, the pairs for which amino-acids can act only as an acceptor or donor, and the pairs for which no flux tubes are possible.

There are two options to be considered.

Option 1: Flux tube in either direction between amino-acids is prerequisite for the existence of the hydrogen bond. In this case the condition is Y(n) = Z(n+k) or Z(n) = Y(n+k).

Option 2: Hydrogen bond is identified as a flux tube. The condition is Y(n) = Z(n+k) and thus stronger than for the first option.

Table 16.1 of Appendix summarizes the allowed and non-allowed pairings for $Y = Z_c$ and Y = Z pairings. To understand the tables some notation conventions must be introduced.

- 1. Let X_{ij} denote the amino-acids in *i*: th and *j*: the column of the code table. i, j = 1, 2 corresponds to hydrophobic amino-acid residues and i, j=3, 4 to hydrophilic amino-acid residues.
- 2. For $Y = Z_c$ option the sets t, T, U, V, W, X are defined as $t = \{phe\}, T = X_{12} t, U = \{tyr, his, asn, asp, cys, arg, ser, gly\}, V = \{trp, gln, lys, glu, gly\}, W = \{gln, lys, glu, trp, arg, gly\}, and <math>X = \{tyr, his, asn, asp, cys\}.$
- 3. For Y = Z option the sets t, T, U, V, W, X are defined as $t = \{met\}, T = X_{12} t, U = \{trp, gln, lys, glu, arg, gly\}, V = \{tyr, his, asn, asp, cys\}, W = \{tyr, his, asn, asp, cys, arg, ser, gly\}, and <math>X = \{gln, lys, glu, trp\}$. ser has been excluded from V since it appears also in the second column of the code table.

Some clarifying comments about the table are in order.

- 1. Pro is an exception since Z nucleotide cannot be represented in this case and Pro can act as donor. This has not been taken into account in the tables.
- 2. The codons coding for the paired amino-acid give additional strong limitations on the pairing unless Z corresponds to quantum superposition of quark pairs associated with the third nucleotide for the codons coding for the amino-acid.
- 3. Depending on option either phe-phe or Met-Met hydrogen bonding is forbidden so that for hydrophobic amino-acids almost all pairings are possible. This might allow to select between the two options or kill both. The special role of met suggest that Y = Z pairing might be the right option. Also the model for DNA as TQC assumes that O = associated with lipids can act as a plug to which two flux tubes terminate. On the other hand, phe is also exceptional in the sense that it is the only amino-acid in X_{12} which has aromatic ring and can act as an acceptor.
- 4. The amino-acids which can act simultaneously as donors and acceptors are of special interest as far interactions between catalyst sites of protein and ligand are considered. Second flux tube could be involved with the structure of the catalyst site and second flux tube with the bonding of between catalyst sites. This kind of amino-acids correspond to $T \times T$, $U \times$

 $U, X_{12} \times W$. For both options hydrophobic amino-acid can be connected with any other hydrophobic amino-acid. In the case that the two amino-acids are connected by two flux tubes one has stronger conditions giving $(Y_1, Z_1) = (Z_2, Y_2)_c$ or $(Y_1, Z_1) = (Y_2, Z_2)$.

- 5. $T \times t$, $U \times V$, and $T \times X$ correspond to pairings for which amino-acids can act as donor or acceptor only. The triplets *abc* in which (a, b) belongs to one of these sets should not appear in alpha helices. For instance, for Y = Z pairing hydrogen bonded *xmety* triplets with x, y in X_{12} should not be possible.
- 6. The hydrogen bonds of alpha helices and beta sheets provide a test for the model. For instance, the appearance of gly in the hydrophobic portions of alpha helices is consistent with both $Y = Z_c$ and Y = Z pairing. The alpha helix appearing as an example in [I130] is consistent with both options.

2. Flux tube is identified as hydrogen bond

Table 16.2 of Appendix summarizes the allowed and non-allowed pairings for $Y(n) = Z_c(n+k)$ and Y(n) = Z(n+k) pairings in this case. The notational conventions are following.

- 1. Let X_{ij} denote the amino-acids in *i*: th and *j*: th column of the code table. i, j = 1, 2 corresponds to hydrophobic amino-acid residues and i, j=3, 4 to hydrophilic amino-acid residues. Only the sets X_{12} and X_{23} are of interest.
- 2. For $Y = Z_c$ option the sets t_1, t_2, V, W are defined as $t_1 = \{phe, pro\}, t_2 = \{met, pro\}, V = \{trp, gln, lys, glu\}$, and $W = \{tyr, his, asn, asp, cys\}$.
- 3. For Y = Z option the sets t_1, t_2, V, W are defined as $t_1 = \{met, pro\}, t_2 = \{phe, pro\}, V = \{tyr, his, asn, asp, cys\}$, and $W = \{trp, gln, lys, glu\}$. ser has been excluded from V since it appears also in the second column of the code table.

Some clarifying comments about Table 16.1 are in order.

- 1. The two options are related by the duality $t_1 \leftrightarrow t_2$, $V \leftrightarrow W$. Pro appears in the list because it contains no N - H group and cannot therefore act as donor. The fact that Pro often appears as first amino-acid in alpha helix conforms with this.
- 2. The codons coding for the paired amino-acid give additional strong limitations on the pairing unless Z corresponds to quantum superposition of quark pairs associated with the third nucleotide for the codons coding for the amino-acid. This could be interpreted as counterpart of wobble base pairing.
- 3. Met (contains S), pro, and phe (only amino-acid with aromatic ring in X_{12}) are exceptional for both options. $X_{12} \times t_1$ and $X_{34} \times t_2 = O (H N)$ hydrogen bonding is forbidden. This poses strong conditions at the boundaries of hydrophilic and hydrophobic regions.

One might hope that either of these models could give a solution to the basic problem of proteonics whether genes code for the protein folding and how: the apparently lost information in the mapping of codons to amino-acids codes for the folding determined hydrogen bonds and more general flux tubes. The hydrogen bonds of alpha helices and beta sheets provide a test for the model. In absence of quantum counterpart of wobble base pairing for Z both models allows to deduce from the mere amino-acid sequence and hydrogen bonding the DNA sequence coding for the protein in the case of alpha helices and presumably also beta sheets. This is of course a testable prediction. For non-hydrogen bonded portions of protein this might not be possible and an interesting question is whether they tend to consist of amino-acids in sets t, V and $t \cup X$ so that hydrogen bonds are not allowed. In any case this would mean a solution to the basic problem of proteomics whether genes code for the protein folding and how: the apparently lost information in the mapping of codons to amino-acids codes for the folding determined hydrogen bonds and more general flux tubes.

Tests for Y = Z and $Y = Z_c$ pairings

The test consists of deducing the number N of pairs which did not satisfy the condition (a(ii), a(ii+4)) not equal to (t, t), or does not belong to $(V \times V)$ or to $t \times V$). From this the average length L of portions satisfying alpha helix conditions k = 4 can be deduced as $L = N/N_{tot}$, where N_{tot} is the number of amino-acids in the sequence.

The test was carried out for one structural unit of asparagine synthetase [I2], xylose isomerase [I31], hydrolase [I16], glutathione s-transferase [I14], and restriction endonuclease BamHI [I3].

1. Option 1: Flux tube from in direction is prerequisite for the formation of hydrogen bond

From **Table 16.6** of Appendix one finds that the test for values of k different from k = 4 for helix gave also surprisingly large values of L(k) for Y = Z option. The average length of alpha helix is 10 amino-acids so that both options could work. $Y = Z_c$ option gives results rather near to this value.

One can apply test also to individual alpha helices. For asparagin synthethase alpha helices correspond to the intervals [7, 28], [76, 84], [130, 155], [170, 177], [76, 84], [170, 177], [182, 194], [256, 268], [277, 284], [297, 305], [309, 314], and [320, 326] in the standard numbering of amino-acids. The test was done for k = 3, 4, 5, 6 assuming that the upper end of tested interval is 6 units higher. N = (0, 0, 0, 0) results for both options for all intervals except for the interval [7, 28] for $Y = Z_c$ for which one obtains N = (4, 2, 3, 3). Hence Y = Z option is favored.

In the case of remaining enzymes only long enough alpha helices were tested and **Table 16.4** of Appendix gives the results

The conclusions are following.

- 1. From **Table 16.4** it seems clear that $Y = Z_c$ option does not work satisfactorily whereas Y = Z option has rather few failures.
- 2. In the case of xylose isomerase and (Y = Z) option with k = 4 there are four helices for which failure occurs for single amino-acid. The prediction is that the corresponding hydrogen bonds are actually absent.
- 3. The worst failure occurs for glutathione s-transferase and involves two amino-acids which are at positions n and n + 4. The hydrogen bonds are predicted to not exist between met-glu and glu-asp in met-glu-asp.

Beta sheets consist of beta strands which can be regarded as (n, n+1) helices so that stability conditions correspond to k = 1. As the **Table 16.5** of Appendix shows, there are no failures for Y=Z option whereas $Y = Z_c$ option has several failures and very bad failure for glutathione s-transferase (3 failures for 4 units long strand).

One might think that loops could contain amino-acids for which the hydrogen bonds to neighbors are not possible. The test for BamHI showed that this is not the case. Only single loop failed for Y = Z option for k = 1, 2..., 4 and this occurred for k = 1.

The remaining test is for whether the Y = Z pairing indeed can fix the DNA sequence completely. BamHI begins as met glu val glu lys glu phe ile..... For beta sheet beginning from second amino-acid requires that the Y=Z rules holds true for subsequent codons in DNA sequence aag ctt cct taa ttc cgg aag... [I4]. By comparing the Z of a given codon in beta sheet to the Y of the next codon inside beta sheet one finds that the Y(n) = Z(n + 1) or Z(n) = Y(n + 1) fails. Similar conclusion follows from an analogous check for the first alpha helix. Situation is saved if the quantum counterpart of wobble base pairing is at work so that the flux tube from tRNA to N - H would in superposition of colors (quark pairs) corresponding to superposition nucleotides Z in codons XYZ for given X and Y coding for the amino-acid in question. Hydrogen bonded amino-acid sequence would behave as if it were coded by the unique DNA sequence. Note that for a given amino-acid X is unique except for leu and arg and Y is unique except for ser. The N - H: s and O =: s for which hydrogen bonds are lacking could form hydrogen bonds with water molecules and O =: s could have long flux tubes with other O =: s in the protein.

2. Option 2: flux tube is identified as hydrogen bond

Tables 16.7 and **16.8** of Appendix summarize the results of the test for Y = Z and $Y = Z_c$ option when flux tube is identified as hydrogen bond. For the first option the average length of

hydrogen bonded interval would be around 5 amino-acids for k = 4 helix for Y = Z and somewhat shorter for $Y = Z_c$. BamHI is exceptional since in this case the length is 16.8 (10.4) amino-acids. for Y = Z ($Y = Z_c$). There is no clear difference between the two alternatives in the case of alpha helices and neither alternative looks promising in this case.

Are = O - O =flux tubes present?

Y = Z option for the folding code assumes that flux tubes can connect acceptor atoms by flux tubes. The pairing would be $Y - Y_c$ pairing considered in the original model as the only possible pairing. In amino-acids only O =: s not acting as acceptors for ordinary hydrogen bonds could have flux tube connections of this kind with each other or other molecules.

- 1. In the case of amino-acids $Y Y_c$ pairing would be between amino-acid in X_{12} and aminoacid in X_{34} part of the code table. These connections would be typically associated with the portions of the protein between alpha helices and beta sheets. The k : th amino-acid (k = 3, 4 or 5) following Pro would be an exception to this rule and this kind of flux tubes could be involved with the long scale stabilization of proteins.
- 2. The O = atom would effectively behave like Y_c . Depending on whether it corresponds to quark or anti-quark, the corresponding amino-acid would be typically hydrophilic or hydrophobic- or rather - able to form hydrogen bonds or not. Since hydrophilic and hydrophobic residues tend to avoid each other the flux tubes in question should be rather long. The phase transitions increasing Planck constant might make this possible. This would bring in a strong long range correlation between the dynamics of the amino-acid residues belonging to the first and third (second and fourth) column of the code table.
- 3. = O O = flux tubes could be also between different proteins. In the case of protein-ligand complex the Planck constant changing phase transition reducing the length of this kind of flux tube could bring proteins together after which a recombination process the hydrogen bond connecting two water molecules would transform the bond to hydrogen bonds of O =: s with water molecules.
- 4. The phase transition increasing \hbar would allow hydrophobic amino-acids to increase their distance from water molecules in a controlled manner. This could be essential for folding and make possible the formation of pockets connected by flux tubes of large \hbar to water. In quantum models for evolution of consciousness these pockets are believed to play a prominent role. Molecular sex in this sense would mean a correlation tending to keep partners at large distance except when \hbar reducing phase transition occurs.

Evolution and amino-acid pairings

The evolution at the molecular level corresponds to the emergence of increasingly complex molecules using as basic building blocks amino-acid chains and non-translated residues attached to them in the post-translational processing of the amino-acid chains. Also increasingly complex reaction paths emerge. Molecular survival and the competition for the metabolic resources at molecular level could be seen as the basic driving force of this evolution.

Typically, in the original situation the enzymes would have received the substrate molecules from the environment but sooner or later this would have become difficult. The solution would have been a synthesis of the substrate from simpler ingredients by starting from some precursor.

If molecules (with magnetic bodies included) are conscious entities able to direct attention, one can imagine that magnetic body controlling them with the mediation of genome and able to actively modify it, could help through modifications of the genome to create to the catalyst a binding site able to bind the precursor. Immune system is doing this very intensively. If the enzyme binding the precursor already exists, a combination of genes coding for the enzyme and the enzyme having the metabolites as ligands could allow to achieve this. All this would reduce to the motor activities of magnetic body, in particular reconnection of flux tubes, a kind of dance of Shiva. Genome would not be anymore a sequence of DNA developing through random mutations under selection pressures. In this framework amino-acids would have appeared before their precursors and possessed some function in RNA world, say the catalysis of join of RNA₂ di-nucleotides to the increasing chain as proposed in [?]. Competition might have led to a situation in which RNA₂ learned to catalyze selectively the generation of amino-acids from much simpler precursors (three of the proposed precursors contain only $C_{,} = O$, and O^{-}) giving rise to positive feedback implying an exponential amplification of RNA and amino-acid populations. The reduced genetic code would have been present at two levels. The reader can decide whether this is a shortcoming of the model or a fundamental biochemical duality.

Can one make any clear cut predictions about preferred mutations?

- 1. In TGD framework mutations are not expected to be always random point mutations but could be even a result of a purposeful action of the magnetic body. Chemical similarity is expected to be conserved in good mutations. This is known to be the case. For Y = Z or $Y = Z_c$ pairing the simplest mutations should leave both Y and Z invariant so that only the first nucleotide X can suffer a mutation.
- 2. Also bi-local mutations of the second and third nucleotides of codons forming Y = Z ($Y = Z_c$) pair and conserving this property might occur and could be crucial for the coherence of the organisms. As found, the formation of flux tube between amino-acids A₁ and A₂ induces a flux tube between nucleotides Y and Z at the corresponding genes. This flux tube could force the possibly intentional mutations to occur as simultaneous mutations of the two genes so that Y = Z ($Y = Z_c$) condition remains true for amino-acids connected by flux tube.
- 3. A new element is that isospin rotation of Z nucleotide $(A \leftarrow G, T \leftarrow C)$ which does not affect amino-acid, affects its folding so that same protein might have different folding patterns and different catalytic properties corresponding to different codons coding for it. This would mean a breaking of the central dogma a the level of magnetic body. Some examples are in order. The mutations Ala/Ser, Ser/Thr, Ile/Val/Leu, Asp/Glu do not change Y. Lys/Arg (A/G), Tyr/Phe (A/U), gly/Ala (G/C), ... are also prevalent and one might hope that they correspond to binary mutations in some important cases.
- 4. Folding is known to be more conserved than amino-acid sequence [I130]. Since folding is a collective property of gene, local chemistry might not be enough and the proposed non-local conservation laws might be needed. Two-point mutations would also correlate the mutations of the binding sites of protein and ligand. For the model assuming two flux tubes per amino-acid, the prediction would be conserved Y = Z ($Y = Z_c$) pairs in genes coding for protein and ligand and these pairs might allow to deduce the paired points. This is consistent with the fact that hydrophobic (-philic) regions tend to be paired in the protein-ligand complex. The paired nucleotides need not belong to the same strand since genes are evenly distributed between strand and its conjugate and characterized by A, G surplus.
- 5. If the flux tubes can connect also side chains, the situation becomes more complex. There is a temptation to think that these flux tubes would connect only the nearby amino-acids of the same peptide and do not therefore affect the large scale dynamics of folding. This would be the case if the value of Planck constant associated with these flux tubes is smaller than for the flux tubes connecting amino-acids as basic units. If flux tubes can begin from the aromatic side chains, the replacement of an aromatic side chain with an aromatic side chain is favored (also chemical similarity explains this). The most basic facts about folding do not provide obvious support for the idea about flux tubes between residues.
 - (a) Hydrophobic residues tend to cluster in dense packing in protein interior (antimatter at quark level) and Val (T), Leu (T), Ile (T), Phe (T), Ala (C), and gly (G) make 63 percent of the interior of protein: the special role of gly (matter rather than antimatter at quark level) is due to the reduction of the side chain to hydrogen atom.
 - (b) Asp (A), Glu (A), Lys (A) and Arg (G) with ionized residues are mostly at the surface of protein and make 23 per cent of protein surface and 4 per cent of interior. As noticed earlier, matter and antimatter at quark level tend to be far from each other. This is consistent with Y = Z pairing between nearby amino-acids and absence of flux tubes between matter and antimatter if there are two flux tubes per amino-acid.

(c) Polar groups tend to be paired by hydrogen bonds and oppositely charged groups tend to be near each other. Acidic Cys residues tend to be in positions where they can form S-S bonds. This can be explained as being induced by Y-Y pairing in the proposed scenario. Aromatic residues tend to have favorable electrostatic interactions with each other and with S, O and amino groups.

16.4 A Simple Quantitative Model For Protein Folding And Catalyst Action Assuming Flux Tubes Between Amino-Acids

Levinthal paradox states that if protein folding is a process in which protein checks for all possible conformations, folding would take astrophysical time. Small single domain proteins with lengths below 100 residues however fold in single step in millisecond time scale and longest folding times are measured in days. This suggests that protein folding is in some sense guided dynamical process and flux tubes would be the natural guides.

It is possible to construct a simple quantitative model for protein folding and catalyst action assuming a long range interaction mediated by flux tubes between amino-acids obeying base pairing rule in some sense. A further assumption is that hydrogen bonds correspond to flux tubes. There are two options to consider.

- 1. If there is only single flux tube per amino-acid the rule implies that conjugate amino-acids are connected by a flux tube: this is conflict with the empirical facts.
- 2. If there are two flux tubes per amino-acid base pairing predicts that amino-adic pairing obeys Y = Z or $Y = Z_c$ rule depending on whether O =: s can act as intermediate plugs for flux tubes or not.

The model is consistent with quantum criticality, and the general vision about 4-D spin glass landscape. The extremals are not completely deterministic just as vacuum extremals of Kähler action and only absolute minimization of energy selects minima. The cautious interpretation is that absolute minimization of energy stabilizes various unstable patterns generated spontaneously by ordinary chemical interactions such as alpha helices and beta sheets. The interpretation of hydrogen bond in terms of flux tube suggests more bold interpretation.

The principle is flexible enough to carry out this purpose but also poses strong constraints on how these patterns integrate to higher level structures. The disappearance of a subset of flux tubes does not spoil the extremal property although it increases its non-determinism and makes folding less predictable and in the case of binding sites it reduces the selectivity of catalyst action. The interpretation would be in terms of molecular ageing. The density of flux tubes can be seen as an analog for the resolution of quantum measurement which is in a fundamental role in quantum TGD, as well as a direct correlate for cognitive and sensory resolutions. The model extends to a model of catalyst dynamics if one the relative motion of reactant molecules is slow in the time scale of folding dynamics so that adiabaticity assumption makes sense. In the following I often use the basic data which can be found from [I130] without explicit reference.

16.4.1 The Model

Let us assign potential energy to the flux tube connecting i: th and k(i): th amino-acid and depending only on the distance $r_{i,k(i)}$. What comes in mind first is the potential energy of harmonic oscillator:

$$V(r) = \frac{kr^2}{2} . (16.4.1)$$

k > 0 corresponds to harmonic oscillator. Also k < 0 is possible in which case the distance between amino-acid and its conjugate tends to be maximized in equilibrium: this option turns out to be the more plausible one and conforms also with the notion of quantum criticality. Besides this there is the constraint that the distances between amino-acid and its follower are constant: $r_{i+1,i} = R$. Using Lagrange multipliers this gives rise to the action

$$L = -E = -\frac{k}{2} \sum_{i} r_{i,k(i)}^2 + \sum_{i} \lambda_i r_{i+1,i}^2 . \qquad (16.4.2)$$

Energy is the negative of this action for static solutions. One could consider also adding kinetic term to this action to describe the dynamics of folding. This action is hoped to give only a qualitative view about folding and the ordinary chemical interactions should fix the details of the folding and select between different folding patterns. Several amino-acid chains could be present and have mutual long range interactions.

If N - H and O = both can be connected by flux tubes, each amino-acid gives two terms to the energy corresponding to the flux tube beginning from N - H and flux tube ending at O =.

The extremals of this action satisfy

$$\frac{\partial L}{\partial r_i^k} = 0 , \ i = 1, ..., N .$$
(16.4.3)

1. If there is only single flux tube per amino-acid, this gives the conditions

$$\lambda_{i+1}\overline{r}_{i+1,i} - \lambda_{i-1}\overline{r}_{i,i-1} = -k\overline{r}_{i,k(i)} ,$$

$$r_{j+1,j} = R .$$
(16.4.4)

The geometric content of these conditions is that the vectors $\overline{r}_{i,k(i)}$, $\overline{r}_{i+1,i}$, and $\overline{r}_{i,i-1}$ are in the same plane.

2. If there are two flux tubes per amino-acid $(= O_i - (N-H)_{k_1(i)})$ and $(N-H)_i - (O=)_{k_2(i)}$

$$\lambda_{i+1}\overline{r}_{i+1,i} - \lambda_{i-1}\overline{r}_{i,i-1} = -k[\overline{r}_{i,k_1(i)} + \overline{r}_{i,k_2(i)}] ,$$

$$r_{j+1,j} = R .$$
(16.4.5)

In this the resultant of the vectors $\overline{r}_{i,k_1(i)} + \overline{r}_{i,k_2(i)}$ would be in the plane determined by $\overline{r}_{i+1,i}$ and $\overline{r}_{i,i-1}$. Note that due to the lack of N - H in Pro it can happen that there is only single flux tube per amino-acid.

Long range interactions of amino-acids with their conjugates would dictate the local folding of the amino-acid chain but extremum property alone does not say much about the lengths of the flux tubes.

Suppose that \overline{r}_i , $\overline{r}_{i,k(i)}$, $\overline{r}_{i,i-1}$, λ_{i-1} are known. Can one solve λ_{i+1} and $\overline{r}_{i+1,i}$? Since the vectors are in the same plane, the linear dependence does not fix the direction of \overline{r}_{i+1} in this plane but only the value of λ_i in this plane once \overline{r}_{i+1} is fixed or vice versa. Therefore the direction in the plane remains un-determined and equations of motion are not fully deterministic as far as extremals are considered. Absolute minimization however eliminates this non-determinism by maximizing the distances $r_{i,i(k)}$ for k > 0 option. The expressions for λ_i result from elementary linear algebra by introducing dual basis of non-orthogonal basis defined by $\overline{r}_{i,k(i)}$ and $\overline{r}_{i,i-1}$.

1. In the case that there is single flux tube per amino-acid, one has

$$\lambda_{i+1} = -k\overline{e}_{i+1} \cdot \overline{r}_{i,k(i)} , \quad \lambda_{i-1} = -k\overline{e}_{i-1} \cdot \overline{r}_{i,k(i)} ,$$

$$\overline{e}_{i+1} \cdot \overline{r}_{i+1,i} = 1 , \qquad \overline{e}_{i+1} \cdot \overline{r}_{i,i-1} = 0 ,$$

$$\overline{e}_{i-1} \cdot \overline{r}_{i+1,i} = 0 , \qquad \overline{e}_{i-1} \cdot \overline{r}_{i,i-1} = 1 .$$
(16.4.6)

The non-determinism does not make it easy to find absolute minimum since non-determinism corresponds to circle $(S^1)^{2N}$ for amino-acid sequence with N flux tube pairings. These conditions do not make sense when $\overline{r}_{i+1,i}$ and $\overline{r}_{i,i-1}$ are parallel: in this case the force must be parallel to $\overline{r}_{i+1,i}$.

2. For two flux tubes per amino-acid one has a slightly more complex expression for these conditions:

$$\lambda_{i+1} = -k\bar{e}_{i+1} \cdot [\bar{r}_{i,k_1(i)} + \bar{r}_{i,k_2(i)}] , \quad \lambda_{i-1} = -k\bar{e}_{i-1} \cdot [\bar{r}_{i,k_1(i)} + \bar{r}_{i,k_2(i)}] ,$$

$$\bar{e}_{i+1} \cdot \bar{r}_{i+1,i} = 1 , \qquad \bar{e}_{i+1} \cdot \bar{r}_{i,i-1} = 0 , \qquad (16.4.7)$$

$$\bar{e}_{i-1} \cdot \bar{r}_{i+1,i} = 0 , \qquad \bar{e}_{i-1} \cdot \bar{r}_{i,i-1} = 1 .$$

The strong resemblance with the dynamics defined by Kähler action predicting spin glass degeneracy associated with vacuum extremals of Kähler action and removed by small deformations to non-vacuum extremals raises the hope that the model indeed catches something essential about the notions of 4-D spin glass degeneracy and quantum criticality.

16.4.2 Basic Mathematical Consequences

Consider first the basic consequences of the variational equations.

- 1. Absolute minimization of energy is very powerful selection principle and expected to choose highly symmetric configurations such as α helices, β sheets, and more complex structures. If combined with adiabaticity assumption it could also allow to understand the dynamics of binding between two proteins and protein and DNA/RNA.
- 2. The extremals of k > 0 action are mirror images of k < 0 action so that the energy minimum for k > 0 is energy maximum for k < 0. If energy minimization is applied also the choice of Y - Y flux tubes, the connected amino-acids should be as near as possible which favors alpha helices and beta sheets. In light of this k > 0 option looks the realistic one. It could however be that for large distances the sign of the potential energy changes. For k > 0 option long flux tubes are not favored by energy minimization. The simplest cure would be large value of Planck constant changing the scale of the potential. If the potential energy changes sign at large distances the situation changes also and $r_{i,k(i)}$ would be as large as possible subject to the condition from fixed chain length.
- 3. If the amino-acid is not paired, it does not experience the long range force and one has

$$\lambda_{i+1}\bar{r}_{i+1,i} - \lambda_{i-1}\bar{r}_{i,i-1} = 0 . (16.4.8)$$

Situation becomes non-deterministic and the portions of the amino-acid chain for which the amino-acids do not have a pair behave like random coils. This is encouraging since this kind of portions are present in folded amino-acids. The absence of N - H from Pro allows to understand the very special role of Pro as being associated with turns of alpha helices and beta sheets.

4. The disappearance of some flux tubes does not destroy a given solution of the conditions but makes it increasingly non-deterministic. The interpretation as a degradation or ageing at molecular level conforms with the interpretation of braiding as a basic characteristic of life. An attractive interpretation of the density of flux tubes is as correlate for resolution for cognition and sensory perception and motor action as counterpart of measurement resolution which is fundamental notion of quantum TGD.

16.4.3 Model For The Helical Structures

 α helix [I130, I1], which is only one member of a rich family of helical structures possible for amino-acid chains, serves as the first test for the model. As a matter fact, the specific properties of α helix are not relevant for the model discussed.

- 1. α helix has nearly vertical NH - O = hydrogen bond between *i*: th and *i* 4: th amino-acid. Also (i, i 3) and (i, i 5) bondings are possible. There are 3.6 residues per turn so that the basic structural unit has 5 turns and consists of 18 amino-acids. One residue corresponds to a vertical translation of 1.5 Angstrom. The chain contains single amino-acid per length of about 3.8 Angstrom and the angular separation of subsequent amino-acids is 100 degrees in the planar projection.
- 2. Isolated α helices are not stable but can be stabilized by secondary coiling: their lifetime is of order $10^{-5} 10^{-7}$ seconds. If the flux tubes are associated with hydrogen bonds, the instability would be naturally due to a reconnection process involving water molecules.

Consider now the model.

- 1. Assume that hydrogen bond is accompanied by a special case of a flux tube resulting in the reduction of the value of Planck constant. Short flux tubes (hydrogen bonds) would connect i k: th, i: th and i + k: th amino-acids, k = 3, 4 or 5. The forces between i k: th and i: th and i + k: th amino-acid compensate each other exactly for an ideal helix so that the conditions are satisfied identically. This kind of mechanism work also for more general helices. Y = Z ($Y = Z_c$) pairing poses special conditions on the helical structures themselves and also on the genes coding for these structures.
- 2. gly helices are consistent with both Y = Z and $Y = Z_c$ pairings. The spontaneous generation of unstable helices in sequences consisting of mere gly could be understood as the instability of gly-gly flux tubes against reconnection with hydrogen bonds connecting surrounding water molecules. Also the sequences consisting of mere Pro can give rise to unstable helices. Pro does not possess N - H and the residue cannot act as a donor in hydrogen bond. This suggests that the residue of Pro can have flux tubes connecting it to O = but not identifiable as ordinary hydrogen bond.

There are also more complex structures formed form helices [I130]. For coiled coils of two or more alpha helices consisting of repeating heptad unit of 7 amino-acids first and fifth aminoacids tend to be conjugates so that horizontal flux tubes connecting first and fifth amino-acids of neighboring could be responsible for the stability and make also possible the hydrophobic bonding between first and fourth residues. Collagen [I9] is a triplet helix and appears as a basic constituent of bones, tendons, skin, ligaments, blood vessels, and supporting membraneous tissues. The units of collagen triple helix consists of very long repetitive sequences of type $(gly - XY)_n$, with a preponderance of Pro for X (also Lys residues are possible). gly-Pro-Y and gly-X-Hyp appear often: here X and Y are arbitrary amino-acids (Hyp denotes hydroxyprolin with O = replaced with OH: this transforms Pro from acceptor to donor). Heating of collagen triple helix unfolds it and converts it to gelatin, in which polypeptide chains are dissociated, unraveled and disordered. Cooling regenerates these conformations for short stretches.

Consider as a example collagen triplet helix [I9] having gly - Pro - Y as a repeating unit. Assume Y = Z or $Y = Z_c$ pairing. Y - Y hydrogen bonds are possible if Y belongs to the group T or U. Only phe $(Y = Z_c)$ or met (Y = Z) is excluded from T. $Y = Z_c$ corresponds to $U = \{tyr, his, asn, asp, cys, arg, ser, gly\}$ and Y = Z to $U = \{trp, gln, lys, glu, arg, gly\}$. This prediction might kill the model. glys can be connected for both options.

1. The first model goes like follows. alpha helix structure is guaranteed by hydrogen bonds between the Y: s inside each collagen unit (k = 3). The amino-acids gly_i , i = 1, 2, 3, are connected by almost horizontal flux tubes cyclically as $gly_1 - gly_2$, $gly_2 - gly_3$, $gly_3 - gly_1$. This cyclic bonding would induce the coiling of alpha helices. The free O =: s of Pros could act as acceptors in the hydrogen bonds with the surrounding water molecules (for instance). For gly-X-Hyp one would have similar structure but Hyp would act as donor in the hydrogen bonds with water molecules. The objection is that if long hydrogen bonds are possible they would have been observed.

2. Second model is based on the philosophy that coiling is a long range effect and must be due to = O - O = flux tubes. gly (Y = G) and Pro (Y = C) can be connected for both options but only by single flux tube by the special properties of Pro: this bonding would give n, n + 4 hydrogen bond of alpha helix. The simultaneous presence of n, n + 3 Y - Y bonds and n, n + 4 pro-gly bonds might be made possible by coiling. Hence the free O = in gly could be connected with a similar O = in the neighboring strand. $gly_1 - gly_2, gly_2 - gly_3, gly_3 - gly_1$ cannot form a closed cycle but the repeating helical pattern $gly_1 - gly_2, gly_3 - gly_1, gly_2 - gly_3$ is possible and could produce the coiling.

16.4.4 Model For β Sheets

beta strands are typically 4-5 amino-acids long structures. Hydrogen bonds are of type (n, n + 1)and β strands have 2 amino-acids per turn so that $\overline{r}_{i-1,i}$ and $\overline{r}_{i,i+1}$ span a vertical plane and the equations of the model are trivially satisfied. beta strands as such are not stable. beta sheets [I5] consisting of β strands which can be either parallel or antiparallel and are glued together by the interactions between residues. beta sheets are also slightly twisted which relates to the chirality of amino-acids. In the antiparallel case strand returns back and forms at the ends of sheet a loop so that so called β hairpin is formed. In parallel case the strand returns as alpha helix to the lower end of the sheet. At the time of writing of [I130] the mechanism of formation of β sheets was not understood.

If horizontal flux tubes between neighboring strands assignable to hydrogen bonds or =O-O= flux tubes between the residues are responsible for the stabilization of the beta sheet structure, then given residue must have two hydrogen bonds with same length to the amino-acids at right and left so that the contributions from right and left side to the force compensate each other and the force is automatically vertical as implied by the twisting angle of π per amino-acid in beta sheet. For self connecting flux tubes inside loops the force would be in the plane of loop and if the force is repulsive loop like structure is expected.

The slight twisting of beta sheet represents a challenge for the model. TGD predicts large parity breaking and thus the twisting and preferred helicity at the level of principle but it is not clear whether the simplest model can explain the twisting.

16.4.5 Secondary Protein Structures

Protein structures are divided into four classes on basis of their secondary structures [I130, I26]. All these structures are consistent with the general model.

- 1. (α) containing only α helices, which must stabilize each other by horizontal flux tubes.
- 2. (β) containing only β sheets both usually antiparallel, which appear always in pairs packing against each other. Horizontal flux tubes connecting the β sheets must act as stabilizers.
- 3. $(\alpha + \beta)$ proteins can contain only single β sheet, usually antiparallel, with α helices clustering together at one or both ends of the β sheet. Antiparallel β sheet stabilizes itself.
- 4. (α/β) in which sheets and helices interact and often alternate along the polypeptide chain. Single parallel β sheet and so called β barrel, kind of sandwich like structure, are basic examples here. The most spectacular barrel consists of 4+4 parallel β strands with α helices outside the barrel.

Concerning the organization of alpha helices and beta sheets to higher level structures the simplest guess is that the large Planck constant flux tubes connecting random coil portions of the amino-acid sequence with each other or with free O = accompanying Pros. The mere assumption that a given portion of coil has only long flux tubes to distant parts of the protein could explain random coil character. The failure of Y = Z condition implies this too. The notion of long hydrogen bond is somewhat questionable and long flux tubes connecting = O: s look more favorable. Also free O =: s inside alpha helices and beta strands could be connected in this manner.

16.4.6 Model For Protein-Protein Binding Sites

Binding sites obey geometric complementarity and are known to resemble protein interior being closely packed. This is also taken to mean that amino-acid chains run parallel to the surface although this statement is not made explicitly in [I130]: one could see binding sites as part of interior which is in a direct contact with exterior, somewhat like a sensory organ like eye. The interface between similar sized proteins is large and tends to be flat (not expected if proteins make sharp turns at the interface rather than running parallel to the surface). Various bonds eliminate electromagnetic interactions at the interface.

The basic mechanism of binding would be based on the reduction of Planck constant for the flux tubes connecting amino-acids. The high flexibility of Y = Z and $Y - Z_c$ pairings -especially in the hydrophobic regions in the center of the binding site where it allows all but met-met and phe-phe flux tubes- makes it an excellent candidate for a folding code.

The question is whether complementary of bonded amino-acids should induce the geometric complementary of the binding sites in the proposed model.

- 1. The binding sites could be connected by only very few flux tubes or flux tubes could connect all amino-acids in a pairwise manner: the first extreme is highly flexible whereas second extreme would produce maximal selectivity. Complementary can thus be partial and its degree is predicted to correlate with the selectivity. The interpretation of disappearance of flux tubes as molecular ageing conforms with the gradual loss of selectivity implying reduced performance of immune system.
- 2. From the example of [I130] about the interface of identical proteins in the quaternary structure of dimer one learns that the geometrically and physically conjugate interfaces of identical monomers pair to form sandwich like structures via so called isologous and heterologous pairings such that valleys and hills fit. The interfaces are reported to resemble closely packed protein interiors and contain hydrophobic residues in the center and hydrophilic residues at periphery. In the case of identical monomers Y - Z and $Y - Z_c$ pairing is possible for a very wide class of amino-acids. The prediction in the case of identical monomers would be that catalyst sites contain only very few amino-acids in the sets V and t defined previously.
- 3. Also the flux tubes between = O atoms could be in key role in the protein-ligand interaction. The interfaces can be thought of as cutting protein along its interior: in center there are hydrophobic amino-acids and in periphery hydrophilic ones. The = O - O = flux tubes would connect periphery of A (B) to the center of B (A). The reduction of Planck constant for would reduce the length of these flux tubes and bring protein and ligand close to each other so that hydrogen bond formation between residues could being. In this process the flux tube connecting O =: s could by reconnection transform to two hydrogen bonds connecting O =: s to water molecules. After the catalysis the reverse of this process would occur.
- 4. For single flux tube between O =: s of amino-acid and ligand the force would be along the line $r_{i,k(i)}$ connecting them. In the improbable case that the amino-acids of protein and ligand are connected by *two* hydrogen bond like flux tubes the force is in the direction of $\overline{r}_{i,k_1(i)} + \overline{r}_{i,k_2(i)}$. The force is predicted to be in the plane spanned by $\overline{r}_{i+1,i}$ and $\overline{r}_{i,i-1}$ for protein and in the corresponding plane for ligand. This is true if the amino-acid sequence at the surface is slightly curved in the direction of the conjugate amino-acid or in opposite direction. This condition is guaranteed by the geometric complementarity.
- 5. The mechanism for the formation of ligand-protein pairs would be very simple: the binding sites of protein and ligand could be coded by same gene or its mutation respecting the Y so that the formation of copies of gene in DNA would be the simplest mechanism to guarantee the prerequisites for geometric conjugation. Geometric conjugation would result automatically if the flux tubes between interior and periphery of binding site determine its shape.
- 6. Slow enough relative motion of molecules induces an adiabatic variation of the shapes of the binding sites so that lock and key mechanism becomes dynamical. The simplest possibility is that binding site and its conjugate behave like two eyeballs gazing each other as proteins

move with respect to each other. This is possible if binding sites are separated from the rest of the protein by random pieces of chain. The analogy with eye might be actually deeper: I have proposed long time ago that directed attention in vision has as a space-time correlate flux tubes of topological light rays or both of these. Wormhole magnetic flux tubes might indeed connect perceiver and the object perceived and serve as correlates of attention in macroscopic length scales.

- 7. Also the hydrogen bonds between residues are important for the protein folding. The donor atoms of the residues can inherit the conjugate of the color of O = and acceptor atoms can inherit the color of N H by temporary reconnection. Therefore also the hydrogen bonds between residues of hydrophilic residues containing both donor and acceptor atoms would be restricted by the colors of atoms and would reflect genetic code.
- 8. Geometric and physical conjugation (acids and basics combine in the interface) means that a virtual protein A+B is cut to pieces along the surface in the interior defining the interfaces. Could this chopping of bigger proteins to smaller ones able to bind allow a realization at the level of genome in the sense that glued portions of protein would originate from same gene or its reversed version and thus satisfy $Y = Z_c$ or Y = Z rule approximately? Could also protein interior involve pairings analogous to catalyst and ligand pairings? This would partially explain why protein folding is more sensitive to the mutations in the interior of protein.

16.5 A Model For Protein Folding Based On Flux Tube Connections Between Water Molecules And Aminoacids

The overall feelings about the model just discussed are somewhat mixed.

- 1. The ideas about flux tube as a correlates for a directed attention and about the connection between hydrogen bond formation and flux tube contraction involving change of Planck constant are attractive. It would be nice if flux tubes between amino-acids could force the portions of amino-acid sequences to form representation about each other in their own geometry. What would be also nice that the notions of finite measurement resolution and cognitive resolution which are fundamental notions of quantum TGD would have direct correlates at the level of flux tube dynamics.
- 2. The model for protein folding involving only flux tube connections between amino-acids satisfying the proposed selection rules has however failures. This could be due to simple fact that the proposed selection rules are quite too restrictive. Also the flux tube connections between amino-acids and water are important and might even determine the folding patterns to a high degree via the induced secondary interactions between amino-acids.

Second model for protein folding to be discussed represents an extreme in which the flux tube connections between amino-acids and water molecules determined the dynamics of the folding. It seems that this model leads to a realistic qualitative picture about folding. Also quantitative model can be constructed as a straightforward generalization of the model involving only the flux tube connections between selected amino-acids.

16.5.1 Could There Be New Physics Behind Hydrophily And Hydrophoby?

One could accept just as a fact that magnetic flux tubes to the magnetic body of water mediate an interaction which is attractive or repulsive between water molecules and amino-acids and attractive between DNA molecules and water. Accepting that this induces interaction between amino-acids one could proceed to model building without any mention about TGD.

One could also try to dig deeper and ask what might be the origin of this interaction.

- 1. **Option I**: Could one understand the interaction in terms of phase transitions changing the Planck constant of the magnetic flux tube. The interaction would be repulsive (attractive) would result if the interaction energy increases (decreases) when Planck constant is reduced. Magnetic interaction energy is certainly the best candidate and could also imply the equivalence of the divisor code and dark baryon code.
- 2. **Option II**: Could hydrophily and hydrophoby be described in terms of em interactions of quarks representing nucleotides in the model of DNA as TQC. For instance, could amino-acids and water molecules be characterized by charges which are of opposite sign for water molecules and hydrophilic molecules and of same sign for water molecules and hydrophobic molecules.

For **Option I**, which represents completely new physics (using the standards of TGD!), the situation looks promising. The magnetic interaction energy assignable to the flux tube is a function of the integers (n_a, n_b) characterizing the corresponding page of the book like structure associated with generalized embedding space - in particular of the Planck constant of the flux tube - and the minimization is performed by keeping the charges of the quarks possibly at its ends fixed. This new physics fits also nicely with the idea that magnetic body controls the living matter by utilizing phase transitions changing Planck constant.

What comes in mind in the case of **Option II** is that the ends of the flux tube carry opposite charges correlating with the codon coding for the amino-acid and giving rise to ordinary gauge interactions. Unfortunately this scenario does not seem to work.

- 1. It was already found that (denoting codons by XYZ) only Y = A, G type amino-acid residue can form hydrogen bonds and is hydrophilic and thus interacts strongly with water and DNA and RNA. If water end of flux tube corresponds to anti-quarks the attractive interaction between quark and anti-quark at the ends of flux tube could relate to hydrophily. For hydrophobic amino-acids one would have interaction between identical quarks and already Fermi statistics would cause repulsion. In DNA as TQC model based on the coding of A, G and T, C in terms of quarks u, d and their anti-quarks hydrophily-hydrophoby dichotomy corresponds to matter-antimatter dichotomy for quark assigned to the ends of the flux tube. Quarks and anti-quark have opposite charges. Hence the flux tube ends of hydrophilic aminoacids could correspond to quarks and water and hydrophobic ends of flux tubes to anti-quarks. Therefore the DNA as TQC model would predict the needed behavior of the forces. In the case of Gly containing only hydrogen as residue the flux tube might be simply absent.
- 2. DNA codons A, T, C, G are bases and thus polar and hydrophilic. In the case of DNA charge conjugation for quarks corresponds to the puridine-pyrimidine complementarity corresponding to conjugation of nucleotides. The rule applying in the case of amino-acids would predict T, C to be hydrophobic nucleotides which does not make sense. Therefore it seems that hydrophily and hydrophoby cannot reduce to the interactions of dark quarks and that they only represent conjugation of nucleotides symbolically.

16.5.2 An Improve Model For Protein Folding

To begin with let us summarize some basic facts about protein folding.

- 1. Hydrophily and hydrophoby play a key role in protein folding and dictate to a high degree the resulting folding patterns. This suggests that one cannot neglect the role of water in the process.
- 2. Protein folding proceeds from short to long length scales starting with the formation of secondary structures such as alpha helices, beta sheets, and random coil portions and is followed by the formation of tertiary and higher structures.
- 3. The formation of hydrogen bonds is in a decisive role in the formation of secondary structures. The mechanism leading to their formation might be contraction of magnetic flux tube by a phase transition changing Planck constant.

- 4. The folding patterns do not depend strongly on the precise primary structure, that is precise amino-acid decomposition which suggests that instead of the detailed chemistry the forces between quarks and anti-quarks mediated by flux tubes is what matter so that hydrophily and hydrophoby would become the basic characterizers of the interaction. The phase transitions changing Planck constant would indeed represent this kind of universal interactions independent of the chemistry.
- 5. In the first approximation amino-acids could be labeled by a variable telling whether it is hydrophobic, hydrophilic, or neither or these (Gly). This approximation would be broken by special amino-acids which appear in edges if beta sheets (Pro) and Cys which often appear as S-S boded pair in junctions. By bringing in forces depending on the angles between tangent vectors of successive amino-acids and on amino-adics themselves this tendency could be modeled.

16.5.3 A Model For Which The Magnetic Body Of Water Is Involved

The alternative approach to protein folding starts from the general vision about magnetic body containing dark matter as a controller of visible matter in living system. The protein and its magnetic body would be regarded as a living system in itself.

- 1. Magnetic body must have large number of flux tube contacts to the visible matter. An excellent candidate for the magnetic body is that assignable with water and having flux tube connections to DNA and both hydrophilic and hydrophobic amino-acids. The magnetic body could control and at least fasten the self-organization process leading to the folding pattern which by applying standard argument would otherwise take astronomical time otherwise. The two-step attractive connections between all hydrophilic amino-acids would be possible via the magnetic body of water. The non-hydrophilic amino-acids not in direct contact with water are known to be more like passive structural stuff responsible for a fixed structure but not so relevant for the functioning of the bio-molecule. Hydrophily and hydrophoby would reflect the dependence of interaction energy on the value of Planck constant associated with the flux tube mediating the interaction.
- 2. This picture implies a straightforward modification of the earlier model. The simplest model would minimize a potential function V expressible as a sum $V = V_1 + V_2 + V_3$ of three terms. V_1 would be sum of the values of a universal two-particle potential function $V_{phi,phi}(r)$ for arguments $r_{ij} = |r_i r_j|$ varying over all hydrophilic amino-acid pairs and giving rise to an attractive force. V_2 would be a sum of a universal two-particle potential function $V_{pho,pho}(r)$ for arguments $r_{ij} = |r_i r_j|$ varying over all hydrophobic amino-acid pairs. V_3 would be would be sum of the values of a universal potential function $V_{phi,pho}(r)$ for arguments $r_{ij} = |r_i r_j|$ varying over all hydrophobic amino-acid pairs. V_3 would be would be sum of the values of a universal potential function $V_{phi,pho}(r)$ for arguments $r_{ij} = |r_i r_j|$ varying over all hydrophobic amino-acids. This potential function would induce a repulsive force. Besides this a constraint force due to the fact that amino-acids form a sequence would be present.
- 3. The resultant of the forces along lines connecting amino-acids would be parallel to the aminoacid sequence in the mechanical equilibrium. Hydrogen bonds and other bonds are indeed formed between neighboring hydrophilic amino-acids and the contraction of the flux tubes connecting the amino-acids in question to the magnetic body of water could be the mechanism. The model seems to be consistent with the basic qualitative facts about folding. The quantitative testing of the model would require determination of the conformations minimizing the potential function subject to the constraint provided by amino-acid sequence. Here of course the freedom to choose the three functions provides a considerable flexibility and symmetry arguments might allow to pose conditions on the form of these functions.
- 4. One could also include to the potential function describing a direct interaction with water molecules depending on parameters like pH affecting the folding pattern. The resultant for a given amino-acid would be sum of forces directed from a hydrophilic amino-acids to neighboring water molecules. It is not clear whether the normal component of this force could be compensated by the induced forces between amino-acids in a typical equilibrium

configuration and the formation of hydrogen bonds involving the contraction of the flux tube could be the manner to achieve this.

The alternative model is more complicated numerically than the model discussed and it would require a considerable amount of work to test it. In particular, the three universal potential functions involve free parameters even if one makes simplifying assumptions about their functional form (say simple behavior under scaling).

16.6 A Model For Protein Folding And Catalytic Action

It would be fascinating if the vision about the role of flux tube connections would generalize to interactions of all molecules in living matter. The mere selection rules would mean hidden simplicity behind extremely complex looking interactions in living matter. The model for protein folding and catalytic action discussed in [K10] is the first attempt in this direction. In the following this model is briefly summarized and the improvement of the model inspired by recent considerations is suggested.

16.6.1 Earlier Model For The Folding Code

The model for the evolution of the genetic code led [?] to the idea that the folding of proteins obeys a code inherited from the genetic code. One can imagine several variants of this code. One of the is that amino-acid behaves like the conjugate Y_c of the middle nucleotide of the codon XYZ coding for it. Conjugation for amino-acids would correspond to the hydrophilic-hydrophobic dichotomy. Also catalyst action could reduce to effective base pairing in this picture chemically and at the level of quarks associated with the flux tube to matter antimatter conjugation. The guess that amino-acid and its conjugate form pairs turned out to be wrong however and after various twists and turns I ended up with the hypothesis that the amino-acid in protein behaves like Y_cZ_c where Z corresponds to third nucleotide for some codon coding for the amino-acid.

It however turned that the model as such is probably too restrictive and not fully consistent in the particular cases studied. In the following this model is discussed briefly and later an improved model for protein folding is proposed.

Flux tubes as correlates of directed attention at molecular level

After some trials one ends up with a general conceptualization of the situation with the identification of ("wormhole") magnetic flux tubes as correlates for attention at molecular level so that a direct connection with TGD inspired theory of consciousness emerges at quantitative level. Whether wormhole flux tubes or ordinary flux tubes are needed is not a completely settled question yet and the attribute "wormhole" will not be used in the sequel. This allows a far reaching generalization of the DNA as topological quantum computer paradigm and makes it much more detailed. The final outcome is very simple quantitative model for both protein folding and catalyst action based on minimization of energy, which seems to be consistent with basic experimental facts as well as general ideas.

What kind of atoms can be connected by flux tubes?

- 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 prerequisite for a hydrogen bond or as 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.

Color inheritance by a reconnection of flux tubes

- 1. There should exist some mechanism allowing amino-acids to inherit the base pairing property from the tRNAs associated with them so that one can identify amino-acid with the middle nucleotide of the codon coding it. If tRNA middle nucleotide is connected to O = of the amino-acid, this becomes possible since the reconnection of flux tubes preserves the "color" of the flux tubes coded by (A, T, G, C) that is by the quark or anti-quark coding for the nucleotide. The temporary formation of a hydrogen bond between N - H and O = of two amino-acids as in the case of alpha helix would allow N - H to inherit the conjugate of the color associated with O =. Alternative interpretation is that this hydrogen bond is possible only if the predetermined color of N - H is consistent with the inherited one. The inheritance of flux tube color would be a completely general mechanism and even the donor atoms in the residues of amino-acids could inherit the color of O = in this manner.
- 2. A possible interpretation for the fixing of the flux tube color is in terms of quantum measurement selecting one color from quantum superposition in the reconnection process. This would mean that the unitary process can bring superposition back and reconnection process can change the inherited color. The hydrogen bonds between water molecules could correspond to quantum superpositions of different colors. This superposition property might relate to the wobble base pairing phenomenon for the third nucleotide in tRNA.

Folding code

The identification of N - H as a representation for the conjugate of the third nucleotide Z means that amino-acids would remember which codon coded them. If only hydrogen bond like flux tubes are allowed, flux tubes can connect only amino-acids satisfying $Y = Z_c$. If = O - O = flux tubes are allowed Y = Z rule favored by the model of DNA as topological quantum computer follows. The isospin symmetry of the third nucleotide implies that both rules are quite flexible. If one identifies hydrogen bond with flux tube (Y(n) = Z(n + k)) the model works badly for both options. If one assumes only that the presence of a flux tube connecting amino-acids in either direction (Y(n) = Z(n + k) or Z(n) = Y(n + k)) is a prerequisite for the formation of hydrogen bond, the model works. Y = Z rule is favored by the study of five enzymes: the possible average length of alpha helix is considerably longer than the average length of alpha helix if gene is the unique gene allowing to satisfy Y = Z rule. The explicit study of alpha helices and beta sheets for these enzymes demonstrates that the failure to satisfy the condition for the existence of hydrogen bond fails rarely and at most for two amino-acids (for 2 amino-acids in single case only).

Y = Z rule could mean a solution of the basic problem of proteonics: Do genes determine the folding of proteins and how this would take place? The interpretation would be that the information loss suggested by the many-to-one character of the genetic code is only apparent. The apparently lost information which corresponds to the A - G and T - C symmetries of the third nucleotide codes for the hydrogen bonding and hence for the folding of the protein. The model in its most stringent form is easy to kill since in the case of alpha helices and beta sheets the hydrogen bonding fixes completely the DNA sequence coding for the protein. A weaker variant of the model based on quantum variant of wobble base pairing: in this case there are no conditions on DNA sequence. It turns out that only this variant works. Hence hydrogen bonded amino-acid behave as if they were coded by the unique codon consistent with Y = Z rule.

Quantitative model

The quantitative model relies on the assumption that the contribution of a flux tube connecting two amino-acids to the potential energy depends only on the distance between the molecules in question. The extremals of the total interaction energy are same for any choice of the potential and only the absolute minimum of the interaction energy depends on the choice of the potential. The simplest potential corresponds to harmonic oscillator potential and would explain formation of alpha helices and beta sheets and with the fact that hydrophilic and hydrophobic residues tend to have a large distance and only few flux tube contacts. For large Planck constant also long flux tubes could correspond to attractive harmonic oscillator potential. Also the contribution of other interactions between neighboring amino-acids are expected to be present but are neglected in the simplest model. The model predicts alpha helices and beta sheets, and more generally, periodic structures, as solutions to energy minimization equations.

The model fails to catch completely the basic rules of protein folding, and the predictions are not fully consistent with empirical facts in the cases studied. A model in which the hydrophilic and hydrophobic interactions are mediated by flux tubes between magnetic bodies of the molecule and water molecule and in this manner induce long range interactions between amino-acids - somewhat like the attractive interactions of electrons with ions induce attractive interaction between the members of a Cooper pair - looks more attractive. This model is however computationally much heavier and is not discussed in [K10]. In the sequel a formulation of this model is discussed.

16.6.2 Hydrophily And Hydrophoby Number Theoretically

Amino-acids can be classified to hydrophilic and hydrophobic ones whereas all DNA codons are hydrophilic. Hydrophily and hydrophoby are believed to relate to the standard chemistry alone and this might be the case. One can however just for fun ask whether hydrophily and hydrophoby could have a connection with divisor code, formation of flux tubes connecting the molecule to water molecules, and phase transitions changing the value of Planck constant and changing the length of flux tube. I have discussed this idea already in the model of protein folding [K10].

To simplify the model assume that only single dark page is associated with water molecule and labeled by (n_a^W, n_b^W) . Of course, several levels characterized by different integers are also possible and this would bring in additional flexibility. Both hydrophoby and hydrophily would mean interaction mediated by the flux tubes to the magnetic body of water with the sign of the force differing for hydrophilic and hydrophobic amino-acids. There is no need to assume that quarks and anti-quarks generate the interaction. Gly for which the residue is just hydrogen atom does not allow classification as a hydrophilic or hydrophobic which would suggest that it does not have any flux tube connections with the magnetic body of the water. The interaction mediated by flux tubes between amino-acids and water molecules would be analogous to the interaction induced by the interaction between electrons and ions inducing attractive interaction between the members of Cooper pair. It would induce attractive interaction between hydrophilic amino-acids and repulsive interaction between hydrophilic and hydrophobic amino-acids favoring the formation of hydrophilic outer surfaces and hydrophobic inner surfaces.

One could understand hydrophily/hydrophoby dichotomy number theoretically for both options. The discussion of the first option makes clear that also second option is possible to realize.

- 1. Assume that n_a^W is divisible by all integers n_a^{DNA} associated with DNA codons and thus involves suitable powers of primes $p \leq 19$. It could contain also an integer factor which is product of primes larger than p = 19. This is necessary for achieving hydrophily of DNA codons.
- 2. Hydrophily of DNA codons also requires n_b^W must be proportional to the product of coprime integers n_b^W (primes for the simplest option) assignable to DNA codons. n_b^W could involve also a factor proportional to second integer expressible as product of primes p > 19. The simplest option is that this integer equals to 1.
- 3. For hydrophobic amino-acids integers n_b^A must be of form $mn_b^A = n_b^{DNA}m_b$ such that m_a does not divide n_b^W and n_b^W . This is enough to guarantee that magnetic flux tubes in

either direction are impossible so that hydrophoby is guaranteed in the proposed sense. This definition extends also to other molecules and can be expressed in terms of the integers (n_a, n_b) labeling the magnetic body of the molecule.

4. Second option is obtained by assigning the integer m_b only to Gly which is neither hydrophilic nor hydrophobic.

16.6.3 Could There Be New Physics Behind Hydrophily And Hydrophoby?

One could accept just as a fact that magnetic flux tubes to the magnetic body of water mediate an interaction which is attractive or repulsive between water molecules and amino-acids and attractive between DNA molecules and water. Accepting that this induces interaction between amino-acids one could proceed to model building without any mention about TGD.

One could also try to dig deeper and ask what might be the origin of this interaction.

- 1. **Option I**: Could one understand the interaction in terms of phase transitions changing the Planck constant of the magnetic flux tube. The interaction would be repulsive (attractive) would result if the interaction energy increases (decreases) when Planck constant is reduced. Magnetic interaction energy is certainly the best candidate and could also imply the equivalence of the divisor code and dark baryon code.
- 2. **Option II**: Could hydrophily and hydrophoby be described in terms of em interactions of quarks representing nucleotides in the model of DNA as TQC. For instance, could amino-acids and water molecules be characterized by charges which are of opposite sign for water molecules and hydrophilic molecules and of same sign for water molecules and hydrophobic molecules.

For **Option I**, which represents completely new physics (using the standards of TGD!), the situation looks promising. The magnetic interaction energy assignable to the flux tube is a function of the integers (n_a, n_b) -in particular of the Planck constant of the flux tube- and the minimization is performed by keeping the charges of the quarks possibly at its ends fixed. This new physics fits also nicely with the idea that magnetic body controls the living matter by utilizing phase transitions changing Planck constant.

What comes in mind in the case of **Option II** is that the ends of the flux tube carry opposite charges correlating with the codon coding for the amino-acid and giving rise to ordinary gauge interactions. Unfortunately this scenario does not seem to work.

- 1. In [K10] it was found that (denoting codons by XYZ) only Y = A, G type amino-acid residue can form hydrogen bonds and is hydrophilic and thus interacts strongly with water and DNA and RNA. If water end of flux tube corresponds to anti-quarks the attractive interaction between quark and anti-quark at the ends of flux tube could relate to hydrophily. For hydrophobic amino-acids one would have interaction between identical quarks and already Fermi statistics would cause repulsion. In DNA as TQC model based on the coding of A, G and T, C in terms of quarks u, d and their anti-quarks hydrophily-hydrophoby dichotomy corresponds to matter-antimatter dichotomy for quark assigned to the ends of the flux tube. Quarks and anti-quark have opposite charges. Hence the flux tube ends of hydrophilic aminoacids could correspond to quarks and water and hydrophobic ends of flux tubes to anti-quarks. Therefore the DNA as TQC model would predict the needed behavior of the forces. In the case of Gly containing only hydrogen as residue the flux tube might be simply absent.
- 2. DNA codons A, T, C, G are bases and thus polar and hydrophilic. In the case of DNA charge conjugation for quarks corresponds to the puridine-pyrimidine complementarity corresponding to conjugation of nucleotides. The rule applying in the case of amino-acids would predict T, C to be hydrophobic nucleotides which does not make sense. Therefore it seems that hydrophily and hydrophoby cannot reduce to the interactions of dark quarks and that they only represent conjugation of nucleotides symbolically.

16.6.4 An Improved Model For Protein Folding

To begin with let us summarize some basic facts about protein folding.

- 1. Hydrophily and hydrophoby play a key role in protein folding and dictate to a high degree the resulting folding patterns. This suggests that one cannot neglect the role of water in the process.
- 2. Protein folding proceeds from short to long length scales starting with the formation of secondary structures such as alpha helices, beta sheets, and random coil portions and is followed by the formation of tertiary and higher structures.
- 3. The formation of hydrogen bonds is in a decisive role in the formation of secondary structures. The mechanism leading to their formation might be contraction of magnetic flux tube by a phase transition changing Planck constant.
- 4. The folding patterns do not depend strongly on the precise primary structure, that is precise amino-acid decomposition which suggests that instead of the detailed chemistry the forces between quarks and anti-quarks mediated by flux tubes is what matter so that hydrophily and hydrophoby would become the basic characterizers of the interaction. The phase transitions changing Planck constant would indeed represent this kind of universal interactions independent of the chemistry.
- 5. In the first approximation amino-acids could be labeled by a variable telling whether it is hydrophobic, hydrophilic, or neither or these (Gly). This approximation would be broken by special amino-acids which appear in edges if beta sheets (Pro) and Cys which often appear as S-S boded pair in junctions. By bringing in forces depending on the angles between tangent vectors of successive amino-acids and on amino-adics themselves this tendency could be modeled.

The earlier approach to protein folding inspired by DNA as TQC idea did not start from this picture but assumed that direct flux tube connections between amino-acids rather than the interactions induced by flux tube connections with the magnetic bodies of water molecules were responsible for the folding. The model did not lead to any spectacular results and the proposed rules were not fully consistent in the cases studied.

16.6.5 The Model For Which The Magnetic Body Of Water Is Involved

The improved approach to protein folding starts from the general vision about magnetic body containing dark matter as a controller of visible matter in living system. The protein and its magnetic body would be regarded as a living system in itself.

- 1. Magnetic body must have large number of flux tube contacts to the visible matter. An excellent candidate for the magnetic body is that assignable with water and having flux tube connections to DNA and both hydrophilic and hydrophobic amino-acids. The magnetic body could control and at least fasten the self-organization process leading to the folding pattern which by applying standard argument would otherwise take astronomical time otherwise. The two-step attractive connections between all hydrophilic amino-acids would be possible via the magnetic body of water. The non-hydrophilic amino-acids not in direct contact with water are known to be more like passive structural stuff responsible for a fixed structure but not so relevant for the functioning of the bio-molecule. Hydrophily and hydrophoby would reflect the dependence of interaction energy on the value of Planck constant associated with the flux tube mediating the interaction.
- 2. This picture implies a straightforward modification of the earlier model. The simplest model would minimize a potential function V expressible as a sum $V = V_1 + V_2 + V_3$ of three terms. V_1 would be sum of the values of a universal two-particle potential function $V_{phi,phi}(r)$ for arguments $r_{ij} = |r_i r_j|$ varying over all hydrophilic amino-acid pairs and giving rise to an attractive force. V_2 would be a sum of a universal two-particle potential function $V_{pho,pho}(r)$ for arguments $r_{ij} = |r_i r_j|$ varying over all hydrophilic amino-acid pairs. V_3 would be would

	A and D	A or D	no flux tubes
$X_{12} \times X_{12}$	$T \times T$	$T \times t$	$t \times t$
$X_{34} \times X_{34}$	$U \times U$	$U \times V$	$V \times V$
$X_{12} \times X_{34}$	$X_{12} \times W$	$T \times X$	$t \times X$

Table 16.1: General structure of pairings for $Y = Z_c$ and Y = Z options. A and D means that both amino-acids can act as acceptors and donors. A or D that only acceptor or donor property is possible.

be sum of the values of a universal potential function $V_{phi,pho}(r)$ for arguments $r_{ij} = |r_i - r_j|$ varying over all pairs of hydrophilic and hydrophobic amino-acids. This potential function would induce a repulsive force. Besides this a constraint force due to the fact that amino-acids form a sequence would be present.

- 3. The resultant of the forces along lines connecting amino-acids would be parallel to the aminoacid sequence in the mechanical equilibrium. Hydrogen bonds and other bonds are indeed formed between neighboring hydrophilic amino-acids and the contraction of the flux tubes connecting the amino-acids in question to the magnetic body of water could be the mechanism. The model seems to be consistent with the basic qualitative facts about folding. The quantitative testing of the model would require determination of the conformations minimizing the potential function subject to the constraint provided by amino-acid sequence. Here of course the freedom to choose the three functions provides a considerable flexibility and symmetry arguments might allow to pose conditions on the form of these functions.
- 4. One could also include to the potential function describing a direct interaction with water molecules depending on parameters like pH affecting the folding pattern. The resultant for a given amino-acid would be sum of forces directed from a hydrophilic amino-acids to neighboring water molecules. It is not clear whether the normal component of this force could be compensated by the induced forces between amino-acids in a typical equilibrium configuration and the formation of hydrogen bonds involving the contraction of the flux tube could be the manner to achieve this.

Could one regard amino-acids and DNAs of given type as analog of species?

An interesting idea raised by the work with the model for protein folding is that the magnetic bodies amino-acids or DNA codon of a given type could behave like single phase on their respective page of the book so that the mutual interactions of their magnetic bodies could affect considerably the behavior of this phase to first order although amino-acids themselves are at different positions and one might expect only small correlations between their motions. Whether the dynamics of amino-acids of given type in protein folding are strongly correlated could be tested.

In certain sense one could speak of single species formed by amino-acids of given type and folding as long range interaction could be seen as an outcome of self-organizing interaction between members of various species and between species themselves plus short range constraints due to the fact that amino-acids form a sequence. The question applies to DNA and RNA codons and also to larger units such as genes formed to which one could assign their own page of the book. Water would represent the page to which all DNAs can send flux tubes. Even the notion of biological species could involve common dark space-time sheet(s) where the magnetic bodies of the members of species are and interact making the members of species to behave like single coherent unit.

16.6.6 Appendix: Tables related to the model of protein folding

Table 16.6 represents the results of the test when flux tube from Y(n) to Z(n+k) or from Z(n) to Y(n+k) is prerequisite for hydrogen bond.

$A \times D$	$no\ flux\ tubes$
$X_{12} \times X_{12}$	$X_{12} \times t_1$
$X_{34} \times X_{34}$	$X_{34} \times V$
$X_{12} \times X_{34}$	$X_{12} \times W$
$X_{34} \times X_{12}$	$X_{34} \times t_2$

Table 16.2: General structure of pairings for $Y = Z_c$ and Y = Z options. A and D refer to acceptor (O =) and donor N - H respectively. Only non-allowed hydrogen bonded pairs are listed.

protein	L(3)	L(4)	L(5)	L(6)
asparagin synthethase				
$Y = Z_c$	11.8	15.0	12.2	13.2
Y = Z	55.0	47.1	47.1	47.1
xylose isomerase				
$Y = Z_c$	10.2	9.7	12.4	11.3
Y = Z	24.8	24.8	16.5	26.4
hydrolase				
$Y = Z_c$	13.8	18.4	16.6	12.8
Y = Z	55.3	20.8	33.2	27.7
glutathione s-transferase				
$Y = Z_c$	12.4	12.4	13.1	15.0
Y = Z	35.0	35.0	26.3	30.0
BamHI				
$Y = Z_c$	9.7	8.5	10.7	10.7
Y = Z	30.4	23.7	30.4	35.5

Table 16.3: The average number L(k) of amino-acids in the portion of amino-acid sequence satisfying the conditions making possible (n, n + k) hydrogen bonding for k = 3, 4, 5, 6 for $Y = Z_c$ and Y = Z option in the case that flux tube can connect Y(n) to Z(n + k) or Z(n) to Y(n + k).

alpha helix	N(Y=Z)	$N(Y = Z_c)$
xylose isomerase		
[74, 93]	(2, 1, 0, 1)(met-lys)	(1, 5, 1, 0)
[111, 129]	(0, 1, 0, 1)(asn-asp)	(2, 1, 0, 0)
[159, 179]	(0, 1, 0, 0)(asp-tyr)	(5, 4, 1, 3)
[201, 223]	(1, 1, 1, 2)(met-tyr)	(4, 3, 4, 3)
[245, 255]	(2, 0, 0, 0)	(0, 1, 1, 0)
[278, 287]	(0, 1, 0, 0)(his-tyr)	(0, 0, 0, 1)
[314, 327]	(0, 0, 2, 1)	(2, 0, 1, 1)
[349, 374]	(0, 0, 4, 0)	(3, 4, 1, 2)
[376, 386]	(1, 0, 0, 0)	(2, 1, 1, 1)
[393, 399]	(0, 0, 0, 0)	(0, 0, 0, 1)
[404, 414]	(0, 0, 0, 0)	(1, 1, 1, 1)
[424, 435]	(0, 0, 1, 0)	(2, 1, 2, 0)
hydrolase		
[39, 50]	(0, 0, 0, 1)	(2, 1, 2, 1)
[60, 79]	(0, 1, 0, 0)(asn-asp)	(2, 2, 3, 1)
[93, 113]	(1, 1, 0, 1)(val-gly)	(3, 0, 2, 1)
[115, 121]	(1, 0, 0, 0)	(0, 0, 0, 0)
[126, 134]	(0, 0, 1, 0)	(1, 0, 0, 0)
[143, 155]	(0, 0, 0, 0)	(0, 0, 0, 1)
glutathione s-transferase		
[12, 24]	(0, 0, 1, 0)	(0, 0, 0, 0)
[65, 76]	(0, 0, 1, 0)	(0, 1, 0, 0)
[83, 108]	(3, 2, 3, 1)(met-glu-asp)	(0, 0, 1, 0)
[111, 134]	(0, 0, 1, 2)	(3, 1, 4, 2)
[150, 166]	(1, 1, 2, 0)(asp-leu)	(1, 1, 1, 0)
[174, 184]	(0, 0, 0, 0)	(0, 0, 0, 1)
[187, 194]	(0, 0, 0, 0)	(0, 0, 0, 0)
BamHI		
[10, 18]	(0, 0, 0, 0)	(0, 0, 0, 0)
[20, 34]	(0, 0, 0, 0)	(0, 1, 1, 1)
[58, 72]	(1, 0, 1, 1)	(0, 0, 0, 0)
[79, 84]	(0, 0, 0, 0)	(0, 0, 0, 0)
[117, 132]	(0, 0, 0, 0)	(0, 0, 0, 0)
[146, 150]	(1, 1, 0, 0)	(0, 0, 0, 0)
[159, 169]	(0, 0, 0, 0)	(0, 0, 0, 0)
[200, 205]	(0, 0, 0, 0)	(0, 0, 0, 0)

Table 16.4: The test for alpha helices of four enzymes. The first column gives the range of amino-acids defining the alpha helix in question. The vectors in second and third column give the numbers of failures for k = 3, 4, 5, 6 for (n, n + k) helix (k = 4 is the most interesting value). The amino-acid-pairs for which the hydrogen bond does not exist for Y = Z option are given.

beta sheet	N(Y=Z)	$N(Y = Z_c)$
asparagin synthethase		
[113, 122]	0	2
[233, 240]	0	0
[245, 255]	0	0
[290, 297]	0	3
xylose isomerase		
[43, 47]	0	0
[96, 100]	0	2
[134, 140]	0	1
[262, 267]	0	0
[291, 295]	0	0
hydrolase		
[14, 19]	0	0
[25, 28]	0	0
glutathione s-transferase		
[3, 7]	0	0
[28, 32]	0	3
[54, 58]	0	0
[60, 63]	0	0
BamHI		
[2, 8]	0	0
[46, 48]	0	0
[70, 72]	0	0
[95, 100]	0	0
[105, 112]	0	0
[138, 144]	0	0
[174, 180]	0	0
[183, 185]	0	1

Table 16.5: The test for beta sheets of four enzymes. The first column gives the range of aminoacids defining the beta sheet in question. The vectors in second and third column give the numbers of failures for k = 1 for (n, n + 1) helix.

protein	L(3)	L(4)	L(5)	L(6)
asparagin synthethase				
Y = Z	4.5	4.9	4.6	4.9
$Y = Z_c$	4.2	4.7	5.3	4.6
xylose isomerase				
Y = Z	3.7	4.3	3.5	3.9
$Y = Z_c$	4.0	3.0	4.1	3.8
hydrolase				
Y = Z	5.7	5.1	4.2	4.3
$Y = Z_c$	4.6	5.0	6.1	5.1
glutathione s-transferase				
Y = Z	5.1	5.8	4.6	4.0
$Y = Z_c$	4.5	3.6	4.0	4.7
BamHI				
Y = Z	11.3	16.8	15.6	12.9
$Y = Z_c$	16.8	10.4	12.1	12.9

Table 16.6: The average number L(k) of amino-acids in the portion of amino-acid sequence satisfying the conditions making possible (n, n + k) hydrogen bonding for k = 3, 4, 5, 6 for $Y = Z_c$ and Y = Z option in the case that flux tube can connect Y(n) to Z(n + k).

alpha helix	N(Y=Z)	$N(Y = Z_c)$
asparagin synthethase		
[7, 28]	(4, 4, 4, 2)	(6, 4, 3, 5)
[76, 84]	(1, 0, 1, 1)	(2, 2, 1, 1)
[130, 155]	(5, 5, 4, 5)	(2, 2, 2, 1)
[170, 177]	(0, 0, 1, 1)	(1, 1, 1, 1)
[182, 194]	(1, 1, 1, 1)	(2, 2, 1, 1)
[256, 268]	(1, 3, 0, 3)	(3, 0, 3, 0)
[277, 284]	(0, 0, 0, 0)	(0, 0, 0, 0)
[297, 305]	(0, 0, 0, 0)	(1, 0, 0, 0)
[309, 314]	(0, 1, 0, 0)	(2, 0, 1, 0)
[320, 326]	(1, 1, 0, 0)	(0, 0, 0, 0)
xylose isomerase		
[74, 93]	(6, 1, 6, 4)	(2, 5, 4, 3)
[111, 129]	(3, 3, 4, 2)	(4, 4, 4, 3)
[159, 179]	(3, 4, 6, 3)	(4, 3, 1, 3)
[201, 223]	(3, 6, 5, 4)	(5, 7, 4, 4)
[245, 255]	(1, 1, 1, 1)	(0, 1, 0, 0)
[278, 287]	(2, 1, 1, 0)(his-tyr)	(0, 0, 0, 1)
[314, 327]	(1, 2, 3, 3)	(2, 3, 2, 2)
[349, 374]	(4, 3, 8, 6)	$(\underline{2}, \underline{3}, \underline{2}, \underline{2})$ (5, 8, 1, 3)
	(4, 0, 2, 3)	(0, 0, 2, 0)
	(4, 0, 2, 3)	(1, 4, 5, 0)
[404, 414]	(0, 0, 0, 0, 0)	(1, 0, 0, 0) $(3 \ 3 \ 1 \ 1)$
	(1, 1, 2, 1) (1, 2, 0, 2)	(3, 3, 1, 1) (3, 2, 3, 1)
	(1, 2, 0, 2)	(0, 2, 0, 1)
hydrolase		
[39, 50]	(2, 3, 0, 2)	(2, 1, 3, 1)
[60, 79]	(4, 2, 2, 4)(asn-asp)	(4, 4, 5, 2)
	(2, 1, 4, 4)(val-gly)	(3, 2, 1, 1)
[115, 121]	(0, 1, 0, 0)	(0, 1, 0, 0)
[120, 134]	(0, 1, 1, 1)	(1, 0, 0, 0)
[[143, 155]	(0, 1, 1, 1)	(1, 0, 1, 1)
glutathione s-transferase		
[12, 24]	(1, 4, 2, 4)	(5, 2, 3, 1)
[65, 76]	(3, 1, 1, 0)	(2, 1, 1, 1)
[83, 108]	(5, 3, 5, 5)	(5, 3, 3, 2)
[111, 134]	(4, 5, 5, 4)	(4, 5, 3, 3)
[150, 166]	(2, 2, 3, 0)(asp-leu)	(4, 3, 1, 3)
[174, 184]	(0, 0, 0, 0)	(1, 1, 1, 1)
[187, 194]	(1, 1, 0, 1)	(0, 2, 0, 1)
BamHI		
[10, 18]	(0, 0, 0, 0)	(0, 0, 0, 0)
[20, 34]	(4, 1, 1, 2)	(2, 5, 4, 2)
[58, 72]	(3, 1, 2, 4)	(3, 5, 4, 1)
[79, 84]	(0, 0, 0, 0)	(0, 0, 0, 0)
[117, 132]	(0, 0, 0, 0)	(0, 0, 0, 0)
[146, 150]	(1, 1, 0, 0)	(0, 0, 0, 0)
[159, 169]	(0, 0, 0, 0)	(0, 0, 0, 0)
[200, 205]	(0, 0, 0, 0)	(0, 0, 0, 0)

Table 16.7: The test for alpha helices of four enzymes in the case of Y(n) = Z(n + k) option. The first column gives the range of amino-acids defining the alpha helix in question. The vectors in second and third column give the numbers of failures for k = 3, 4, 5, 6 for (n, n + k) helix (k = 4 is the most interesting value).

beta sheet	N(Y=Z)	$N(Y = Z_c)$
asparagin synthethase		
[113, 122]	1	5
[233, 240]	3	0
[245, 255]	1	0
[290, 297]	0	1
xylose isomerase		
[43, 47]	0	1
[96, 100]	2	4
[134, 140]	2	0
[262, 267]	2	1
[291, 295]	0	1
hydrolase		
[14, 19]	1	2
[25, 28]	0	0
glutathione s-transferase		
[3, 7]	0	1
[28, 32]	1	3
[54, 58]	4	1
[60, 63]	0	0
BamHI		
[2, 8]	0	0
[46, 48]	0	0
[70, 72]	2	0
[95, 100]	0	0
[105, 112]	4	0
[138, 144]	0	0
[174, 180]	0	0
[183, 185]	1	2

Table 16.8: The test for beta strands of four enzymes for Y(n) = Z(n+1) option. The first column gives the range of amino-acids defining the beta sheet in question. The vectors in second and third column give the numbers of failures for k = 1 for (n, n + 1) helix.

Chapter 17

Getting philosophical: some comments about the problems of physics, neuroscience, and biology

17.1 Introduction

This contribution was inspired by an FB discussion and is an attempt to summarize basic philosophical problems of biology and neuroscience and the TGD based solution of them. One cannot actually bypass basic philosophica problems of recent day theoretical physics so that the discussion begins with these. I wrote first version of this contribution 2018 and this version year later.

17.1.1 Importance of philosophical thinking

The FB discussion that motivated this work once again made manifest both the extreme importance and regrettable lack of philosophical thinking - not only biology but in natural sciences in general. I do not mean with philosophical thinking academic philosophy, which I have found mostly deadly boring. Rather, for me good philosophical thinking means posing critical questions - rather than personal insults.

What we really know and what we do not know? What do we believe and what part of this is just beliefs? Are there facts challenging these beliefs? What is consciousness: is it really a property of something as "-ness" suggests? What is free will? How it manifests itself? Is it an essential aspect of consciousness so that AI hype could be forgotten? Are free will and non-determinism really in conflict with physics as physicalist has decided to believe? Concerning consciousness, what guidelines come from modern, physics, biology, and neuroscience?

In physics critical thinking would have allowed to avoid the numerous fads and fashions that have plagued us during last 4 decades: GUTs that led to the wrong track, inflation theory, various ad hoc models of dark matter postulating some exotic strong AI, supersymmetry in its GUT form, superstring models, loop gravity,...

Critical thinking would have challenged various "interpretations" of quantum theory and we could have continued immediately the work of the fathers of quantum theory rather than waiting for almost a century. Critical thinking would have also inspired the question whether the non-determinism of state function reduction has something to do with free will and how one should generalize the ontology of physics (Copenhagen ontology gives is it up altogether) to build a logically consistent framework.

Unfortunately critical thinking tends to lengthen the time spent in academic assembly line so that it is strongly discouraged. Thinkers tend also to become isolated from their social groups since everyone of us wants desperately to belong to some group and this requires sharing of its beliefs. It is easier to believe what professor and text book tell and get the research position and funding.

People are also very lazy. AI scientist decides that consciousness is running computer program or a property of the network structure or something equally ad hoc: no need to learn huge amount of physics, biology, neuroscience. Biologist decides that biology is nothing but Schrödinger equation and electromagnetism (or mere chemistry as in the older variant of the belief still prevailing). Neuroscientist desides that physicalism is correct and brain is the seat of the consciousness module. Brain as a computer paradigm makes the situation even easier. Physicist decides to believe in physicalism stating in its modern version that all physics reduces to Planck length scale: one can safely forget all other branches of sciences as a kind of taxonomy and specialize to apply one particular algorith to build CV.

17.1.2 Basic dogmatics

The key dogmas common to all branches of natural science are physicalism and reductionism. Physicalism states that matter is all that matters and consciousness is mere epiphenomenon and that world is deterministic - in the quantum version of the dogma it obeys statistical determinism. Reductionist sees natural sciences are a victorious march towards shorter and shorter space and time scales. Science is an imperium that grows conquest by conquest.

We are told that super string theorists have taken the last step to Planck scale by building the only possible theory of everything. This step is really gigantic: from electroweak length scale there are 16 orders of magnitude to Planck length scale. Before this every order of magnitude has contained a lot of su4prises but now the situation would be different as already GUT theorists revealed to us.

The surprise was however that the theory in Planck length scale does not allow to predict anything in long length scales: situation is like trying to predict the behavior of initial value sensitive system. The question of philosopher would be obvious: could something have gone wrong? This question has been made by some theoreticians. The decision of elite however seems to be that physics has reached its end. Nothing can be predicted and we should be happy about this marvellous feature of the only possible theory.

This series of conquests is marked by transitions. From biology to biochemistry, from biochemistry in vivo to organic chemistry in vitro, from chemistry to molecular physics, from molecular physics to atomic physics. Then follows a transition from atomic physics to nuclear physics: the assumption is that these two physics have practically nothing to do with each other. There are numerous experimental anomalies found during the last century challenging this belief. "Cold fusion" people were labelled next to criminals for their scandalous claims. Luckily the situation has now changed. But people talking about water memory belong still to the pariah of science.

After this jump we jump from nuclear physics to hadron physics to physics at quark-gluon level and then comes the really really big Planck jump. So simple.

There is however a little problem. Every successful conqueror must build a lot of bridges, without them the maintenance fails. Reductionistic conquerors were so hasty that they did not have time to to build the bridges between these different physics. We do not understand how nuclear physics emerges from hadron physics emerges from quark physics. We do not understand how biochemistry emerges from organic chemistry emerges from molecular physics emerges from atomic physics. But we can decide that this is only a technical difficulty: if we had enough computational power we could fill these gaps.

Actually, I know a couple of finnish fellows who tried to fill a gap. The first one has read from text book that the notion of chemical bond emerges from atomic physics. He wrote a lot of computer programs and did not find a slightest indication for this. Second fellow had learned that cell membrane emerges and started to study a model in which one has just molecules and molecular dynamics simplifying the situation. Not a slightest indication.

17.2 TGD inspired view about the basic problems of physics, neuroscience, and biology

A reaction to not so thoughtful comments of a young otherwise friendly fellow in FB inspired me to ask why the young people who have got through the basic courses are not only ignorant but sometimes also - well - arrogant. Why they are ignorant is easy to understand but arrogance remains a mystery for me. Personally I was also extremely ignorant as also the my fellow students but quite too shy to be arrogant: could I have been as arrogant as other if I had not been so hopelessly shy? This fellow had not understood much of what I had written - something completely acceptable, understandable, and predictable since something completely new is in question and text book wisdom or what professor said is simply not enough.

So he concluded that I am writing only weird fairy tales and that it seems that I have never heard about mathematics, electrodynamics, or thermodynamics. According to him these fields allow to understand biology more or less completely: maybe he read this from a text book or professor told this to him. My FB friend also wanted to know whether I have read any book about biology during my lifetime.

I responded that I have not only heard the word "biology" but have even written about quantum consciousness and quantum biology [K5] (1000+ something pages). I forgot to mention that I have also written two published books about TGD [K140, K8] and there are 17 online books at my homepage (9 of them about quantum biology) (see http://tinyurl.com/yddldhoe and http: //tinyurl.com/ycokk2kh) plus numerous articles both published articles- in particular in journals edited by Huping Hu - and at my homepage (see http://tgdtheory.fi/tgdarticlesall.html). I told that I have also recently published a long article in a book published by Springer about adelic physics [L74, L75] (see http://tinyurl.com/ybzkfevz): the goal of adelic physics is to describe the correlates of cognition and consciousness in terms of number theory and whose most important applications are to biology.

I informed that I have also heard the word "thermodynamics" and even developed what I call p-adic thermodynamics providing a first principle approach to particle massivation replacing Higgs mechanism [K86] (see http://tinyurl.com/y9z83aob). I forgot to mention that quantum TGD can be seen formally as a complex square root of thermodynamics replacing Boltzman weights with the complex square roots defining vacuum functionals and that the generalization of so called microcanonical leads to extremely predictive view about scattering amplitudes serving as the building bricks of zero energy states [L91] (see hhttp://tinyurl.com/yakzlllk).

This discussion was not pleasant but very useful in that it inspired me to write a summary of basic philosophical problems of biology and neuroscience and the TGD based solution of them. I hope that I have not forgotten anything from the list.

Importance of philosophical thinking 17.2.1

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In the following the attention is restricted mostly to the philosophical problems of biology and neuroscience. It however turns that these problems are actually also problems of physics.

17.2.3 Nothing but biochemistry and electromagnetism?

The basic dogmatics says that life is nothing but chemistry plus a little bit of electromagnetism needed to model cell membrane and neuronal membrane. There is also EEG but this is taken as noise due to neural circuits so that there is no need to waste time with it. Luckily, not all experimentalists know or care about dogmatics and have found correlations of EEG with behavior and physiology and they are used as a diagnostic tool. Most of them however refuse to consider seriously the possibility that EEG might possibly communicate something from brain somewhere. Where would this somewhere could reside: outside brain?

No! Philosopher must be producing totally weird fairy tale now! Says the mainstreamer inside me with such a friendly ut delicate tone that it becomes clear that he regards the poor philosopher as a screwball.

But philosopher continues asking. Didn't Libet discover that our sensory data is fraction of second old? Could it take fraction of second of this data to propagate as EEG signals from brain to this something. As a matter fact, Libet discovered also that the conscious decision to raise finger is preceded by neural activity starting for a fraction of second earlier. One cannot understand this unless one decides that it supports the absence of free will.

Philosopher asks also whether our decision that experienced time and the time of physicist are one and the same thing is be wrong. They are indeed different in many respects as any first year physics student understands. Should we trust facts instead of textbook wisdom? And what about Libet's second finding: could we give up our firm decision that signals propagate in only single direction of geometric time?

There is also a second strange electromagnetic phenomenon in biology: bio-photons. Already discovered almost century ago, they are still taken as pseudoscience by many biologists. They appear in visible and UV range but it seems that they are not produced in molecular reactions (this would mean peaks in the distribution). What is their origin?

Why vivo-vitro difference? 17.2.4

Even the basic dogmatist must admit that one must speak about organic chemistry in vivo and in vitro. In vitro one can build models for reactions, deduce estimates for the excitation energies of molecules, construct thermodynamical models for reactions in terms of thermodynamics involving parameters like activation energies and chemical potentials, one can develop complex networks of reaction pathways.

The typical assumption of these models is that everything is homogenous and isotropic: one has spatially constant concentrations of various reactions obeying differential equations determined by the kinetics. One can however construct more complex structure by allowing diffusion making possible spatial gradients.

The problem is that this dynamics has very little to do with what happens in living cell. The in vitro estimates for the rates of reactions are many many orders of magnitudes too low as compared to those in living matter. We do not understand anything about bio-catalysis. We know that enzymes and ribozymes somehow make the miracle but that's all. We do not have slightest clue about how reactants manage to find each other in the molecular soup full of different molecules. We have no idea wherefrom the reactants get the energy to jump over potential wall making the reaction quite too slow.

Philosopher would say that here is an excellent opportunity for new physics to enter in biology. How can reactants find each other? Could they possibly be connected by something, which shortens as the reactants meet? Could the notion of tensor network involving quantum entanglement be essential element of biology and entire physics. Particles would not be lonely riders but could be connected by something at least temporarily. Could this something liberate energy quanta allowing to get over the potential wall making reaction so slow? Could these networks have dynamical topology and make living systems what they are.

Unfortunately, standard space-time picture does not allow this something. Also Planck constant is quite too small. Should we conclude that the philosopher is weirdly fairytaling again?

17.2.5Where does the coherence come from?

A further mystery is how the biochemical reactions can occur coherently in length scales longer than atomic scale. Without this coherence I could not write this, play piano, or even raise my hand. If we were just sacks of water containing some chemicals we would be doing science and arts. We would be indeed just sacks of water containing some chemicals in chemical and thermodynamical equilibrium and microscopic sample from this water would characterize us completely.

Mysteriously the coherence of biodynamics in scales up to the size of the organism emerges somehow. The required coherence need not be quantum coherence - and probably it is not - but it could be induced by quantum coherence. Quantum coherence of what? There is also the problem due to quite too small value of Planck constant. We have learned about the effects supporting the vision about quantum biology. It is now however becoming clear that these effects would however require large value of Planck constant.

Here the philosopher remembers the findings of Blackman and other pioneers of bio-electromagnetism. They found that the irradiation of vertebrate brain by ELF radiation at EEG frequencies scale had effects on both behavior and physiology and these effects look quantal occurring at harmonics of endogenous magnetic field of .2 Gauss. $E = h \times f$ makes these effects extremely small and totally masked by thermal noise. What if the value of Planck constant were so large that the energies were above thermal energy?

Philosopher talks shyly about effective Planck constant $h_{eff} = n \times h_0$, where h_0 is the minimal value of h_{eff} and n is integer: h_0 would be actually the real value of Planck constant and h_{eff} would be associated with space-time surfaces, which are in number theoretic approach n-sheeted covering spaces [L66, L75, L74] and replaced at QFT limit with single slightly curved piece of M^4 . n can be identified the dimension of extension of rationals assignable to the space-time surface and measures algebraic complexity. There are arguments that ordinary Planck constant is given by $h = 6h_0$ [L52, L84].

Now the mainstream physicist inside us is getting really angry: is this recklessly speculating philosopher really suggesting that our cherished quantum theory might not be the final word of science?

The dynamics of space-time surfaces

This dynamics predicts two kinds of space-time regions [L43] (see http://tinyurl.com/yboog5sr.

- 1. The regions of first kind are locally minimal surfaces. These minimal surfaces are as 4-D analogs of geodesic lines analogs of asymptotic states of particle physics for which interactions are not on. They also satisfy non-linear geometrization of massless field equations so that both particle and wave aspects are present. What is especially important is that static minimal surfaces have vanishing mean curvature and look like saddles locally. They cannot be closed surface if stationary.
- 2. Second type of regions are not minimal surfaces: there is a non-trivial coupling of the minimal surface term to 4-force density analogous to the divergence of Maxwellian energy momentum tensor. This is a generalization of the dynamics of a point-like charged particle in Maxwell field. These regions are identified as interaction regions: in particle physics these two regions correspond to external free particles and the interaction region. Magnetic flux tubes play fundamental role in TGD based quantum biology are deformations of string like objects, which represent simplest 4-D minimal surfaces.

Essential is the coupling between induced Kähler form (mathematically like Maxwell field) and the geometry of the surface: the divergence of energy momentum current assignable to the analog of cosmological term (4-volume) equals to the divergence of that assignable to Kähler action: this expresses local conservation of four-momentum. One could also speak about coupling between Kähler field and gravitational field: Penrose's intuition about the role of gravitation in biology would be correct.

When the coupling is absent, minimal surface property implies the separate vanishing of both divergences and separate conservation of corresponding energy-momenta. All the known extremals of Kähler action are minimal surfaces: this is due to their very simple algebraic properties making easy to discover them. Physically this correspond to quantum criticality: dynamics is universal and does not depend on coupling parameters.

Biocatalysis

As already mentioned, bio-catalysis remains a total mystery in bio-chemical approach. Magnetic body carrying dark matter could provide the needed mechanisms. Actually these mechanism would be also basic mechanisms behind water memory and - dare I say it aloud? - homeopathy [K62].

According to TGD view about catalysis, reactants find each other by cyclotron resonance for dark cyclotron radiation assignable to massless extremals (MEs) possibly associated with Ushaped flux tubes. The U-shaped flux tubes of the molecules reconnect to a pair of flux tubes connecting the molecules. This occurs only if the flux tubes have same strength of magnetic field and therefore same thickness by flux quantization. The same value of h_{eff} guarantees resonance. The next step is the shortening of the flux tubes by a reduction of h_{eff} and liberating the energy kicking the reactants over the potential wall making the process extremely slow otherwise.

DNA replication, transcription to RNA, and translation of RNA to amino-acids are the fundamental processes in biology and TGD should provide a general model for them. Consider DNA replication as an example.

- 1. The standard model assumes that DNA opens and nucleotides build up the DNA codons in ordered manner. Nucleotides would be caught one-by-one from the environment by U-shaped flux tubes from DNA reconnecting with similar flux tubes from nucleotides. In the proposed model however dark codons are the fundamental units and expected to induce the process at the level of chemistry. Dark codons do not allow a decomposition to letters. Therefore ordinary codons rather than nucleotides should serve as basic units in energy resonance binding them to dark codons (triple resonance or ordinary resonance with respect to the sum of resonance energies). This looks like a problem for both replication and transcription. Translation in which RNA codons are paired with amino-acids suggests a solution of the problem.
- 2. Suppose that dark codons are the basic units also in the environment, and are connected by long flux tubes with rather large h_{eff} to ordinary nucleotides forming thus loose but actually strongly correlated triplets. Nucleotides would serve as basic units only apparently: the entities in question would be analogous to tRNA codons. In the replication and transcription the dark codons of opening DNA sequences would form flux tube contacts with dark codons in the environment coupled to ordinary loose codons by dark triple resonance.

After that the Planck constant h_{eff} associated with the connecting flux tubes would be reduced, the flux tubes would shorten and the complementary dark codon would be drawn near the dark codon associated with DNA. Also the flux tubes connecting the dark codon to the nucleotides would shorten and the codon and complementary codon would form 3 base pairs. Shortening by a reduction of h_{eff} would provide the energy making the process fast enough. The loose codon property would allow to store the energy needed to make the reaction fast.

3. This model can explain also the claim of Montagnier *et al* [L17] about remote DNA replication [L17, L83]. Gariaev *et al* have reported the same process much earlier [I113] and together with Peter Gariaev we have developed a model for the process [K149].

The situation is as follows. One has two vessels A and B: A contains genes and B only nucleotides. The vessels are connected by channels so narrow that the genes cannot leak through them. The system is irradiated at 7 Hz frequency, which is near the lowest Schumann frequency. The generation of the copies of genes in B is reported.

The proposed model suggest that the flux tubes emanating from the dark DNA codons associated with the opening DNA extend to the other side - possibly through the channels so that there is a strong correlation between the directions of flux tubes and their endpoints are close to each other. If they have same value of h_{eff} they would have same length. They would reconnect with dark codons at the other side connected to nucleotide triplets by long flux tubes and the process would continue in the same manner as in the ordinary replication.

What selected the biomolecules?

Now philosopher is asking why only very few candidates for relevant biomolecules are actually selected. Who/what selected and how? This leads to very unpleasant questions circumvented by deciding that the emergence of life was nothing but a thermodynamical fluctuation. It has however become clear that complex organic molecules are present even in interstellar and intergalactic space. The miraculous thermodynamical fluctuation explaining evolution without real evolution would have been really huge.

Philosopher tends to conclude that we simply have no clue about what selection at the biomolecular level really is and continue that some new physics is involved so that it is time to think giving up the reductionistic narrative.

The selection problem appears also at the level of biochemical reaction pathways. One can imagine endless variety of "reaction vertices". If one assumes that only very few basic "reaction vertices" are allowed but the rest not, one can construct a limited number of reaction pathways. But this is an ad hoc assumption: this selection of allowed reaction pathways certainly occurs but we do not have a slightest idea about the physics behind it.

There is also an analogy with computer science. One can construct endless variety of linguistically correct computer programs: why only very few of them would be selected. And with neuroscience: from a huge array of behavioral patterns only some are selected.

Here one can of course try a loophole: Darwinian selection. But there is no selection in the Universe of physicalist. This would require free will and intentionality. The trick does not work.

But what about this network in which biomolecules are connected by this something already mentioned?, asks philosopher. Could this something connect only biomolecules if they are in the same relationship as sender and receiver of radio signal. Could these somethings connect stably only systems possessing common resonance frequencies? Could this criterion could select both the preferred biomolecules and the "reaction vertices" and thus also reaction pathways.

One can develop this idea further.

1. The resonance between systems with the same value of h_{eff} would be both frequency - and energy resonance. The resonance between systems with different values of h_{eff} requires change of h_{eff} of either system so that h_{eff} is same for the systems. Energy is conserved, which means that the frequency of the photon would change to satisfy $E = h_{eff,1}f_1 =$ $h_{eff,2}f_2$. One would have only energy resonance.

The resonance of dark matter states with bio-molecules would be energy resonance and make it possible for long scales to control short scales by inducing molecular transitions. The transformed photons could have interpretation as bio-photons [K20, L28].

2. One can however argue that mere resonance is not enough to select bio-molecules. Magnetic flux tubes containing dark particles can vary their thickness and by the conservation of the monopole flux also magnetic field and cyclotron frequency so that they can get in resonance with any bio-molecule. A stronger condition is required.

The obvious idea is that also biomolecules can be in resonance and surviving bio-molecules are able to build networks. Selection would not be selection of mere individuals but that of networks able to co-operate. There would be a choir singing resonantly in unisono rather than only resonating pairs. The biomolecules involved would have common transition energies which would poses extremely strong conditions on survivors.

It is easy to guess the reaction of the mainstreamer: fairy-taling again.

Genetic code

Genetic code definitely represents information. Is it really an outcome of thermodynamical fluctuation? Is there some deep mathematics associated with the genetic code?, asks the philosopher now. Be patient!

Genome contains also intronic portion: most of it consists of introns and the intronic portion is the larger the higher the evolutionary level is. The prevailing interpretation has been as "junk". Is it really junk?, wonders philosopher. Luckily, the attitude that trash bin represents the highest level of evolution has begun to slowly change to more rational one. Could there be a beautiful mathematics behind genetic code? Could it be something similar to codes in computer science and have not only one representation - the chemical one - but numerous representations? If computer science would have developed before genetics - this question would have been completely natural and we would probably know a lot about these representations. Could this dark matter with large Planck constant at these mysterious somethings identified by our philosopher tentatively as magnetic flux tubes realize the really fundamental representation of the genetic code and also of of DNA, RNA, tRNA, and amino-acids (AAs) in information theoretic sense? And could also radiation provide realization of genetic code necessary for communications? This is what the philosopher claims [L44, L80, L79, L32, L92].

The most plausible vision at this moment is that since magnetic body is the boss, chemical code should be incomplete secondary representation of more fundamental genetic code realized at the level of magnetic body controlling bio-matter. The realizations based on 3-proton triplets and dark light 3-chords defining icosa-tetrahedral representation of the genetic code in terms of Hamiltonian cycles [L97] would be the deeper realizations. There would be several Hamiltonian cycles distinguishing assignable to the same chemical representation of the genetic code. The analogy with music suggests that the realization in terms of 3-chords defining bio-harmony gives rise to quantum correlates of emotions assignable to magnetic body as kind of higher level sensory perceptions. Genetic codon as 6-bit unit would correspond to the "bitty" aspects of intelligence and harmony would correspond to emotional intelligence as the holistic aspect of intelligence [L97, L32]. Emotions would be realized already at the level of magnetic body [L86, L82].

The recent 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) supports 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 is a poorly understood in standard biology and could be based on emotional states lasting for several generations. This is natural in ZEO [L32, L102].

How different representations of the genetic code relate to each other?

- 1. The natural hypothesis is that given dark codon generates corresponding light 3-chord in communications and control. Alike likes alike rule of homeopathy suggests that triple resonance between identical codons is the basic mechanism of communications between various representations. Similar codons of DNA sequences would be in resonance if the mood defined by bio-harmony is same for them. For the same value of h_{eff} one would have both energy and frequency resonance for different values only energy resonance.
- 2. The condition that all possible or at least some moods coded by Hamiltonian cycles are realized, poses additional conditions on ordinary DNA codons since given codon should be able to respond to several 3-chords resonantly. An open question is whether ordinary codons responds via triple resonance or to the energy associated with the sum of the three frequencies in which case one can consider the possibility that the sum of frequencies does not depend of bio-harmony.
- 3. Since dark protons are entangled and do not allow a decomposition to letters, it is not possible to realize the correspondence with ordinary codons by assigning a frequency separately to each nucleotide: the chemical codon reacts as a holistic entity [L97]. This gives highly non-trivial conditions on transcription and DNA replication: DNA and RNA nucleotides must form loose codons connected to dark codon by long flux tubes and in transcription/replication these flux tubes shorten. This allows to understand [L17] also the remote replication of DNA reported by Montagnier *et al* [L17]. The loose codons formed by nucleotides and dark codons would be very similar to tRNA codons except that the flux tubes connecting dark codon to nucleotide would be long.

17.2.7 Metabolism

Metabolism is one of the key aspects of biology. We must eat and plants must busily photosynthesize in order to survive. But why metabolic energy feed is needed? Again a mystery.

Non-equilibrium thermodynamics

Non-equilibrium thermodynamics is one attempt to answer this question. Thermodynamical equilibrium is completely uninteresting, entropy is maximal and in the case of local dynamics the state of system is completely determined by a small sample of it. However, if one has energy feed, situation changes since equilibrium becomes flow equilibrium. The energy feed guarantees that there is macroscopic dynamics rather than mere thermal motion at microscopic level.

Also in this case one has essentially the same situation everywhere unless one introduces macroscopic parameters - also energy flow - depending on time and position to get something more interesting. Simple reaction kinematics determined by differential equations can be replaced with that determined by partial differential equations obtained by allowing diffusion. Also temperature, pressure and other thermodynamical parameters can be allowed to depend on position and time. Turing proposed a model for the coloring of Zebra as outcome of this kind of dynamics. The model for neuronal membrane and nerve pulse generation is also a rough model trying to reproduce basic facts about nerve pulse generation using thermodynamics for neuronal membrane regarded as a capacitor. This is of course a mere parameterization of the situation. TGD leads to a quantum model for the situation [K103]. Also the interpretation about the role of nerve pulse patterns at neuronal level changes dramatically [L65, L86].

In non-equilibrium thermodynamics one speaks of self-organization. One can generalize this notion to quantum self-organization and the crucial criticality associated to the transitions between different self-organization patterns generalizes to quantum criticality [K108]. Could these transitions correspond to spatio-temporal self organization patterns, behaviors, functions, programs. This in turn leads to deep connections with conformal symmetry (even its generalization in TGD), fractality, and universality of the dynamics. It is a pity that biologists do not seem to know much about these possibilities.

Now the philosopher starts to talk about ontology. Try to be patient. In standard physics the 3-D time= constant snapshot defines the state. This belief has led to weird proposals: in quantized general relativity one ends up with a proposal that there is no time at all.

ZEO based view about quantum self-organization

Could it be that 4-D deterministic time evolution between initial and final states could be more fundamental than the 3-D snapshot? Could superpositions of these 4-D evolutions define quantum states. If so, the state function reductions would occur between these superpositions and their non-determinism would be consistent with the determinism of field equations. Free will would not break laws of physics. It would be like starting new deterministic computer program. Our philosopher calls this ontology Zero Energy Ontology (ZEO) and claims that it leads to a theory of consciousness as a generalization of quantum measurement theory [L77] (see http://tinyurl.com/ycxm2tpd). Irritating.

ZEO based quantum measurement theory predicts that in ordinary state function predicts that the arrow of time changes in ordinary state function reductions but is preserved in "small" state function reductions identifiable as analogs of so called weak measurements. The recent strange findings of Minev *et al* [L98] provide direct evidence for the change of the arrow of time in state function reductions of atomic systems [L98].

ZEO predicts also the possibility of signals propagating backwards in time. This led to the vision that episodal memories involve communications with the brain of geometric past [K106], to the idea that motor actions and sensory perception are time reversals of each other [L93]: motor action would involve sending of negative energy control signals to the geometric past, and to the notion of remote metabolism based on quantum credit card mechanism. One can say that the system sends negative energy to a system able to receive it rather than receiving positive energy.

The energy of system as a function of h_{eff} increases when other parameters are kept constant. It costs energy build intelligence. h_{eff} for a given sub-system tends also to reduce spontaneously. Hence there must be continual energy feed to keep the level of conscious intelligence. A highly interesting possibility that this condition applies to all self-organizing systems. Selforganization generates long range coherence and requires energy feed. Could it be that dark matter makes itself visible by giving rise to long range correlations and coherence induced by dark matter at the magnetic body of the system [L107]?
Just as life also self-organization involves generation of coherence in long scales and requires energy feed. In the model for living system relying on dark matter as $h_{eff} = n \times h_0$ phases at magnetic body of the system coherence is induced by quantum coherence of the dark matter, and metabolic energy feed is required to increase h_{eff} tending to reduce spontaneously. Could self-organization be quite generally modelled in the same manner so that dark matter would make itself visible in everyday physics [L107]? Could the realizations of the genetic code in terms of dark nuclei and dark photon 3-chords be involved with the self-organization of water and be involved with morphogenesis?

Does metabolic energy feed generate conscious information?

The basic question about the role of metabolic energy remains, says the philosopher. What is its real role? Energy feed generates structures and structural complexity means information. It seems that metabolic energy feed involves also a feed of information or generation of information. And because living systems are in question, philosopher cannot avoid the question whether this information is actually conscious information. Is there any other kind of information than conscious information?!

To this question standard physics has no answer: it can only describe entropy mathematically and identification of information as lack of entropy is the easy answer suggested in lack of anything better. The question about a possible measure for conscious information analogous to Shannon entropy is one manner to end up with p-adic physics as a correlate of cognition and the necessary fusion of real and various p-adic physics leads to adelic physics [L74, L75]. Adelic physics in turn predicts - surprise- surprise - a hierarchy of phases of matter labelled by the value of Planck constant $h_{eff}/h_0 = n$ defining the dimension of the extension of rationals defining the adele. These phases residing at these somethings defining the networks - magnetic flux tubes - make possible macroscopic quantum coherence inducing the coherence of living matter.

Quite generally, the energies of states as function of h_{eff} increase. For instance, atomic binding energy scales decreases like h_{eff}^2 and cyclotron energies scale like h_{eff} . In order to generate phases with non-standard value of h_{eff} energy feed is needed. This energy is identifiable as metabolic energy.

In adelic physics [L75, L74] h_{eff} serves as a measure for the IQ of the living system in welldefined system. The higher its value, the better changes the system has for generating conscious information - and also for destroying it. This leads to a rather concrete view about the origin of good and evil. The ethics and moral are simple: good deed increases the conscious information of the universe. Conscious entity can choose whether to increase the conscious information of the universe or reduce it. Evil deeds indeed lead to a reduction of conscious information of the universe since the doer cannot confess others or even himself what he did. Also the members of community become secretive - complex encryption schemes develop. The self-knowledge of the universe knows is reduced. Luckily, evolution unavoidably occurs in statistical sense and resources of conscious information increase in long enough time scale.

Remote metabolism as a purely thermodynamical universal mechanism in ZEO

Quite recently (towards end of 2019) I found a more precice formulation for the intuitive notion of remote metabolism, which strongly suggests that energy is conserved in ZEO. There is a decomposition to system and the energy energy source: call them A and B. Intuitively, A receives energy from B by sending negative energy to B. What does this really mean?

- 1. A "big" (ordinary) state function reduction reversing arrow of time takes place: this would correspond to sending negative energy signal to past. The energy of A+B in the final time reversed state at new passive boundary of CD would be shared in new manner such that one can say that A has received from B the metabolic energy.
- 2. Energy would be conserved. I have also considered the interpretation that the total energy of the system associated with CD increases [K85] [L114]: since CD itself breaks Poincare invariance, it seems that one cannot exclude this. However, the Poincare invariance is realized at the level of moduli space for the positions of the either boundary of CD, and one can assume energy conservation. Even the wave functions at the boundary of CD can be taken to be

in the representations of Lorentz group acting as its isometries. Plane waves correspond to wave functions in the moduli space for the boundary of CD keeping second boundary fixed.

3. To make this more precise one must define metabolic energy more precisely by introducing the hierarchy of Planck constants and the fact that the increase of h_{eff} of sub-system keeping other parameters constant increases it energy. Second law means that A tends to loose energy due to the decrease of h_{eff} for its sub-systems. This is true also for the time-reversed state but in opposite direction of geometric time so that with respect to standard direction of time the energy increases. This would provide extremely general purely thermodynamical mechanism of remote metabolism.

A model of protocell based on Pollack effect

I learned about extremely interesting Quanta Magazine article (http://tinyurl.com/y34o784j) telling about findings related to water droplets as protocells able to perform chemical metabolism as a transfer of molecules to exterior and back. See

The work is carried out by David Zwicker and collaborators at the Max Planck Institute for the Physics of Complex Systems and the Max Planck Institute of Molecular Cell Biology and Genetics, both in Dresden. The report about the work is published in Nature Physics.

In a simplified model for the droplets (P-granules in C-elegans cell is the real life example) the proteins in droplet can be in two states: in state A the stay in droplet and do not get out but can enter to the droplet from outside. In state B they can get out from droplet. To get into state B energy such as sunlight would be required.

TGD suggests a concrete counterpart for the droplet as exclusion zones (EZs) induced by energy feed such as radiation in water in Pollack effect. EZs are able remove inpurities from interior in conflict with second law. TGD based explanation of the mystery is change of the arrow of time induced by TGD counterpart of ordinary state function reduction in zero energy ontology (ZEO): self-organization would be dissipation with reversed arrow of time at at the magnetic body (MB) of system acting as master and forcing time reversed evolution at the level of ordinary bio-matter serving as a slave.

TGD suggests for the model of protocell as droplet a realization as exclusion zone (EZ) generated in Pollack effect.

1. The exclusion zones (EZs) discovered by Pollack [I137, I115, I21, I82, L36] (http://tinyurl.com/oyhstc2) behave just like this. TGD allows to build a model of the Pollack effect [L36] (http://tinyurl.com/gwasd8o). The formation of EZs requires water bounded by a gel phase and they are negatively charged. Their really strange feature is that they throw out impurities just like state B in the model: this seems to defy second law telling that gradients tend to disappear. This makes possible primitive chemical metabolism involving exchange of chemicals between droplet and exterior. Light signal initiating the transfer by providing the metabolic energy needed. Transfer would stop as light signal stops.

In TGD inspired quantum biology EZs are in crucial role. For instance, cell is negatively charged as also DNA double strand. Interpretation as EZs is natural.

- 2. The explanation for the negative charge of EZ is that part of protons and possibly other ions go to magnetic flux tubes forming the magnetic body (MB) of the system [L87, L111] (http: //tinyurl.com/yyyk6fu8 and http://tinyurl.com/yjhx9xp7). Dark ions form phases with nonstandard value $h_{eff} = n \times h_0 > h$ of effective Planck constant as cyclotron Bose-Einstein condensates. This system has long length scale quantum coherence and serves as a master controlling bio-chemistry, which is in the role of slave. This forces the mysterious coherence of the ordinary bio-matter impossible in life-as-mere-chemistry approach.
- 3. MB could control chemical metabolism of the droplet by sending dark photons to the droplet transforming to bio-photons and generating EZ state in the droplet and initiating transfer of molecules to the outside. The transition reducing the value of h_{eff} at MB would bring protons back to EZ droplet and it would become normal again. Second law would force the molecules from outside to diffuse back to the droplet.

4. There is still one hard problem to be solved. What causes the mysterious removal of impurities from EZ challenging second law? Here zero energy ontology (ZEO) comes in rescue [L112] (http://tinyurl.com/wd7sszo). In ZEO macroscopic quantum jump corresponding to ordinary state function reduction changes the arrow of time. This would occur to MB as EZ is formed. Second law holds still true but in reverse time direction. MB is the boss and forces time reversal also at the level of ordinary bio-matter. The usual diffusion of molecules to cell occurs but with reverse arrow of time and explains the mysterious removal of impurities observed by Pollack for EZs.

All biological self-assembly processes would use this mechanism. In fact, self-organization quite generally would be dissipation in reverse direction of time: this would explain self-assembly aspect of self-organization. The big quantum jumps would inducing change of the arrow of time would tend to increase of h_{eff} in statistical sense (h_{eff} is identifiable number theoretically essentially as the dimension of extension of rationals and bound to increase in statistical sense). This would correspond to the evolutionary aspect of self-organization [L75, L87]. The increase of h_{eff} requires energy since the energy of state increases with h_{eff} with other parameters kept constant. Energy feed is therefore needed. Dark matter n TGD sense would make itself visible in everyday life.

17.2.8 The mystery of replication

Replication is one of the deepest mysteries of biology. It is really something totally counterintuitive if cell is seen as a sack of water plus some chemicals. We have a lot facts about what happens in the replication at DNA level but how this miracle happens is a mystery. At cell level the situation gets even more complex.

Philospher thinks that behind the chemistry there might lurk a much simpler quantum dynamics and that chemistry only makes its best to mimic this deeper dynamics. Is biochemistry controlled by something? Does this something provide a template for the dynamics at chemical level? The idea about the presence of this something popped up already in the mystery of EEG. What could this something perhaps receiving sensory information from vertebrate brain and maybe providing feedback as control signals affecting also chemistry?

Now our brave philosopher attacks the length scale reductionism again. Isn't it quite too much to require that all these replications in different length scales would result as accidental "emergence" due to thermodynamical fluctuations? Could the dynamics be fractal with essentially same patterns - for instance replication - occurring in different scales. Could this dynamics be induced by what happens on this something.

Philosopher also suggests a concrete model for the controlling level: dark matter with large value of Planck constant $h_{eff}/h_0 = n$ at magnetic flux tubes and asks whether the conjectured dark realization of DNA in various scales performs the fundamental replication inducing in turn the biological replication in various scales as a mimicry? This would simplify the situation enormously but in totally different manner than length scale reductionism. Morphogenesis controlled by the hierarchy of dark realizations of genetic code would be the basic vision (see http://tinyurl.com/ yalny39x). This would simplify the situation enormously but in totally different manner than length scale reductionism.

TGD suggests also a purely topological element involved with replication. Magnetic body (MB) could replicate [K99]. Replication would be like 3-vertex of Feynman diagram representing the decay of a particle to two particles. MB or part of it regarded as particle like entity splits into two. The incoming 4-surface and two outgoing 4-surfaces meet along 3-D surface common to all three. After that various molecules would self-organize around the resulting templates. This could happen also for the MB of dark DNA in replication and induce the bio-chemical part of replication.

17.2.9 Morphogenesis

The problem of structure formation in biology - morphogenesis - was put under the rug by most biologists after the emergence of genetics. Sheldrake [L19, I120] is one of those who have taken it seriously and has been labelled as a crackpot by mainstreamers (I have discussed Sheldrake's views from TGD point of view in [L19, L49]). One just assumes that the structures are there and performs chemistry around these structures. This approach is very practical and has given an enormous amount of data but very little understanding.

In standard physics the description of spatial structures would be in terms of enhanced densities of biomolecules or of their gradients in some space-time region. This is the only possibility because the space-time of standard physics is topologically and geometrically utterly trivial. Empty Minkowski space is an excellent approximation for it.

What philosopher has to say about this? If space-time topology were topologically nontrivial, situation would change dramatically. Already Wheeler saw this possibility and in the biology inspired by TGD (for which Wheeler suggested its name) all structures correspond to structures of topologically non-trivial space-time identified as surface in certain 8-D space-time: space-time sheets, magnetic flux tubes, etc... The entire TGD inspired quantum biology relies on this vision. The structures that we see around us would represent the non-trivial topology of space-time surface.

All structures - including bio-molecules, membrane like structures, organelles, organs, ... - would be 4-D space-time surfaces. Again philosopher gets excited since this would reduce the notion of shape in biology to a precisely defined and testable geometrodynamics coupling to em fields.

General view about morphogenesis

The new view about space-time lead to a rather general view about morphogenesis.

1. The presence of the Kähler field (em field is sum of Kähler field and second term) makes possible flow equilibria such as cell membrane, which are not minimal surfaces. These surfaces can be closed and stationary making possible isolation from environment crucial for living organisms.

Spherical soap bubble is a good analogy: it is not minimal surface as the soap films spanned by frames are. They look locally like saddle surfaces with opposite external curvatures in two orthogonal directions, this implies that they cannot be closed surfaces. Bubble is not possible without a pressure difference Δp between the interior and exterior of the bubble: the blowing of the soap bubble generates Δp , and means external energy feed analogous to metabolic energy feed.

 Δp is analogous to a non-vanishing voltage V over cell membrane. The electric field of cell membrane and the energy feed providing the energy of electric field as metabolic energy are essential for the stability. More generally, V would generalize to non-vanishing of energy momentum tensor of Kähler field with non-vanishing divergence serving as a correlate for the energy transfer between Kähler and volume (gravitational) degrees of freedom.

This generalises to all morphologies, which correspond to closed surfaces. They necessarily involve both Kähler electric and magnetic fields coupling to the geometry to stabilize the morphology. This statement would give some content for the exaggerated claim that biology is nothing but electricity + Schrödinger equation that I heard during my first student year.

2. For instance, the presence of Kähler electric field can correspond to electric fields of cell membrane or along a part of body. If it is too weak, things go wrong in development. As was found decades ago, consciousness is lost if the electric field between frontal lobes and hindbrain gets too weak or has wrong direction [J17]. Cell dies if the membrane potential becomes zero and EEG disappears in death. Also microtubules have electric field along their axes essential for their existence.

Michael Levin and his collaborators [I104, I105, I129] have discovered further fascinating connections between electric fields and morphogenesis. One of the discoveries is that the electric fields of the embryo are controlled by neurons of the still developing brain (see http://tinyurl.com/y77fcc7r). This conforms with the view that neurons and their MBs correspond to a higher level in the hierarchy than ordinary cells and there take care of control in longer scales. The MB of the developing brain would be the controller.

3. A non-trivial coupling (four-momentum transfer) between the volume and Kähler degrees of freedom requires that the energy momentum currents have opposite and non-vanishing divergences. For the energy momentum tensor of ordinary Maxwell field the divergence is proportional to the contraction of Maxwell current and Maxwell field so that the current must be non-non-vanishing.

In TGD the energy momentum tensor is replaced with energy momentum current allowing to have well-defined notion of energy momentum and corresponding conservation laws. Now the divergence contains two terms. The first one is the contraction $Tr(T_K H^k)$ of energy momentum tensor T_K of Kähler action with the second fundamental form H^k : this term proportional to T_K is new. Second term is proportional to the contraction $j_K J \nabla h^k$ of the induced Kähler form J with Kähler current j_K and gradients ∇h^k of embedding space coordinates analogous the divergence of energy-momentum tensor $j^{\beta} F^{\alpha}_{\ \beta}$ in the case of ordinary Maxwell action. One expects both terms to be non-vanishing.

For the mere Kähler action, which I believed for decades to determine the preferred extremals, j_K is either vanishing or light-like. In presence of coupling it can be both non-vanishing and time-like. The realization that cosmological term is present was forced by the twistor lift of TGD whose existence is possible only for $H = M^4 \times CP_2$ [K132, L76].

4. The predicted stabilizing Kähler (and em) currents would naturally correspond to the DC currents flowing along the body in various scales discovered already by Becker [J98, J17] and found to be essential for the survival of the organism. In particular, Becker's DC currents are essential for the healing of wounds and in the regeneration of organs. In the first first aid stage of the healing DC currents are generated locally and after than central nervous system (CNS) takes care of the generation of the current (for TGD based discussion of Becker currents see [K99] (see http://tinyurl.com/ydg6okkk) or [K101]). Also this is easy to understand from the proposed stability criterion.

This picture is discussed quantitatively in the framework of the twistor lift TGD in [L54] [L90].

Is genetic code involved with morphogenesis?

The chemical realization of the genetic code tells virtually nothing about morphogenesis. Could morphogenesis emerge via a general self-organization process having no dependence on genetic code? For instance, cell membrane consists of two lipid layers and soap films emerge spontaneously, and do not involve chemical genetic code.

TGD strongly suggests that quantum theory of self-organization replaces non-equilibrium thermodynamics so that the increase of h_{eff} generating dark matter is crucial for all self-organization processes involving dark matter in TGD sense: there would be no sharp distinction between living and inanimate matter. Furthermore, Pollack effect suggests that the dark phases of water could realize dark proton representation of the genetic code. Also the realization in terms of dark photon triplets is possible. Could morphogenesis rely on non-chemical realization of genetic code in long length scales?

Remark: In TGD also ordinary nuclei correspond to nuclear strings. Could genetic code be realized even at this level?

17.2.10Hen-or-egg questions of biology

Standard biology suffers from several hen-or-egg problems. Which came first: genes or metabolism? The problem is that genes require metabolism and metabolism requires genes! Genes-first leads to the vision about RNA world and metabolism-first to lipids world idea.

The emergence of basic biomolecules is the second problem. What selected these relatively few basic molecules from huge multitude of molecules? Again hen-or-egg problems emerge. Which came first: proteins or the translation machinery producing them from RNA? Did RNA arrive before proteins or did proteins and RNAs necessary for their transcription and translation machinery emerge first. One can argue that ribozymes served as catalysts for RNA replication but how RNAs managed to emerge without replication machinery involving ribozymes? What about DNA: did it emerge before RNA or could it have emerged from RNA? It seems that something extremely important is missing from the picture.

TGD predicts the existence of dark variants of basic biomolecules DNA, RNA, tRNA, and amino-acids (AAs). One can ask whether something very simple could be imagined by utilizing the potential provided by dark variants of bio-molecules present already from beginning and providing both genes and metabolism simultaneously.

One can start from a couple of observations which forced myself to clarify myself some aspects of TGD view and also to develop an alternative vision about prebiotic period.

1. Viruses are probable precedessors of cellular life. So called positive sense single stranded RNA (ssRNA) associated with viruses can form temporarily double strands and in this state replicate just like DNA (see http://tinyurl.com/yc5f8b3t). The resulting single stranded RNA can in turn be translated to proteins by using ribosomal machinery. RNA replication takes place in so called viral replication complexes associated with internal cell membranes, and is catalyzed by proteins produced by both virus and host cell.

Could ribozyme molecules have catalyzed RNA replication during RNA era? For this option AA translation would have emerged later and the storage of genetic information to DNA only after that. There is however the question about the emergence of AAs and of course, DNA and RNA. Which selected just them from enormous variety of options.

2. Lipid membranes are formed by self-organization process from lipids and emerge spontaneously without the help of genetic machinery. It would be surprising if prebiotic life would not have utilized this possibility. This idea leads to the notion of lipid life as a precedessor of RNA life. In this scenario metabolism would have preceded genes (see http://tinyurl.com/ y7ehv8cq and http://tinyurl.com/y8nltb9e). The basic objection against both genes-first and metabolism-first options is that they need each other!

Consider now the situation in TGD.

1. In TGD framework the dark variants of DNA, RNA, AA, and tRNA would provide the analogs of genes and all basic biomolecules. They would also provide a mechanism of metabolism in which energy feed by (say) solar radiation creates so called exclusion zones (EZs) of Pollack [L36] in water bounded by a hydrophilic substance. EZs are negatively charged regions of water giving rise to a potential gradient (analog of battery) storing chemically the energy provided by sunlight and the formation of these regions gives rise to dark nuclei at magnetic flux tubes with scaled down binding energy.

When the p-adic length scale of these dark nuclei is liberated binding energy is liberated as metabolic energy so that metabolic energy feed giving basically rise to states with nonstandard value $h_{eff}/h = n$ of Planck constant is possible. For instance, processes like protein folding and muscle contraction could correspond to this kind of reduction of h_{eff} liberating energy and also a transformation of dark protons to ordinary protons and disappearance of EZs.

The cell interiors are negatively charged and this is presumably true for the interiors of lipid membranes in general and they would therefore correspond to EZs with part of protons at magnetic flux tubes as dark nuclei representing dark variants of basic biomolecules. Already this could have made possible metabolism, the chemical storage of metabolic energy to a potential gradient over the lipid membrane, and also the storing of the genetic information to dark variants of biomolecules at the magnetic flux tubes formed in Pollack effect.

2. In TGD framework biochemistry would have gradually learned to mimic dark variants of basic processes as a kind of shadow dynamics. Lipid membranes could have formed spontaneously in water already during prebiotic phase when only dark variants of DNA, RNA, AAs and tRNA, water, and lipids and some simple bio-molecules could have been present. The dark variants of replication, transcription and translation would have been present from the beginning and would still provide the templates for these processes at the level of biochemistry.

Dark-dark pairing would rely on resonant frequency pairing by dark photons and darkordinary pairing to resonant energy pairing involving transformation of dark photon to ordinary photon. The direct pairing of basic biomolecules with their dark variants by resonance mechanism could have led to their selection explaining the puzzle of why so few biomolecules survived.

This is in contrast with the usual view in which the emergence of proteins would have required the emergence of translation machinery in turn requiring enzymes as catalyzers so that one ends up with hen-or-egg question: which came first, the translation machinery or proteins. In RNA life option similar problem emerges since RNA replication must be catalyzed by ribozymes.

3. Gradually DNA, RNA, tRNA, and AA would have emerged by pairing with their dark variants by resonance mechanism. The presence of lipid membranes could have been crucial in catalyzing this pairing. Later ribozymes could have catalyzed RNA replication by the above mentioned mechanism during RNA era: note however that the process could be only a shadow of much simpler replication for dark DNA. One can even imagine membrane RNAs as analogs of membrane proteins serving as receptors giving rise to ionic channels. Note however that in TGD framework membrane proteins could have emerged very early via their pairing with dark AA associated with the membrane. These membrane proteins and their RNA counterparts could have evolved into transcription and translation machineries.

DNA molecules would have emerged through pairing with dark DNA molecules. The difference between deoxi-ribose and ribose would correspond to the difference between dark RNA and dark DNA manifesting as different cyclotron frequencies and energies making possible the resonant pairing for frequencies and energies. Proteins would have emerged as those proteins able to pair resonantly with dark variants of amino-acid sequences without any pre-existing translational machinery. It is difficult to say in which order the basic biomolecules would have emerged. They could have emerged even simultaneously by resonant pairing with their dark variants.

17.2.11How life began?

The central question of biology is "How life began?" and dark variants of biomolecules suggest not only a solution to various paradoxes but also a concrete answer to this question.

The transcription machinery for rRNA including ribozymes and mRNA coding for the proteins associated with ribosomes is central for the translation. The DNA coding for rRNA is associated with nucleolus (see http://tinyurl.com/yavahwzt) in the center of the nucleus.

- 1. After the emergence of the first ribosome the ribosomes of the already existing nucleus can take care of the translation of the ribosomal proteins. But how could the first ribosome emerge? This question leads to a paradox bringing in mind self-reference - the basic theme of Gödel-Escher-Bach of Douglas Hofstadter, perhaps the most fascinating and inspiring book I have ever read. The ribosomal proteins associated with the first ribosomes should have been translated using ribosome, which did not vet exist!
- 2. Could the translation of the first ribosomal proteins directly from the dark variants of these proteins solve the paradox? The idea of shadow dynamics induced by the pairing of basic biomolecules with their dark variants even allows to ask whether the replication, transcription, and translation could occur at dark level so that dark genes for ribosomes would be transcribed to dark ribosomal RNA and dark mRNA translated to dark AA associated with the ribosomes. These in turn would pair with ordinary ribosomal RNA and AA.
- 3. But what about dark variants of ribosomes? One can encounter the same paradox with them if they are needed for the translation. Could it be that dark variants of the ribosomes are not needed at all for the translation but would only give rise to ordinary ribosomes by the pairings basic biomolecules and their dark variants. Dark DNA would pair with dark mRNA, which pairs spontaneously with dark tRNA. Once the ordinary ribosomes are generated from the dark ribosomes by pairing, they could make the translation much faster.
- 4. There is however a problem. Both dark RNA and AA correspond to dark nuclear strings. Dark tRNA realized as nuclear string in the proposed manner does not have a decomposition to dark AA and dark RNA as ordinary tRNA has. The pairing of dark tRNA and dark

mRNA should rise to dark AA and dark nuclear string - call it X - serving as the analog for the pairing of mRNA sequence with "RNAs" of tRNAs in the ordinary translation.

5. How to identify X? Could the translation be analogous to a reaction vertex in which dark mRNA and dark tRNA meet and give rise to dark AA and X? X cannot be completely trivial. Could X correspond to the dark DNA?! If so, the process would transcribe from dark DNA dark RNA and translate from dark RNA and dark tRNA AA and dark DNA. This would lead to an exponential growth of dark DNA and other dark variants of bio-molecules. This exponential growth would induce exponential growth of the basic bio-molecules by pairing. Life would have emerged! No RNA era or lipid era might be needed. All basic biomolecules or their precursors could emerge even simultaneously - presumably in presence of lipids - but this is not the only possibility.

One can take a more precise look at the situation and try to understand the emergence of biomolecules and their basic reactions as shadows of the dark variants of bio-molecules appearing in dark particle reactions. The basic idea is that same dark reaction can give rise to several reactions of biomolecules if varying number of the external dark particles are paired with corresponding bio-molecules. Under what conditions this pairing could occur, is left an open question. Consider now the dark $2 \rightarrow 2$ reactions and possible reactions obtained by pairing of some particles.

1. The reaction

 $DmRNA+DtRNA \rightarrow DAA + DDNA$

gives rise to translation mRNA+tRNA \rightarrow AA if DDNA-DNA pairing does not occur in the final state but other dark particles are paired with the their ordinary variants. If only DmRNA-mRNA and DDNA-DNA pairings occur, the reaction gives the reversal mRNA \rightarrow DNA of transription.

It should be easy to check whether this is allowed by the tensor product decomposition for the group representations associated with dark proton triplets [L44]. Same applies to other reactions considered below.

If the reaction is possible then also the reversal

 $\mathrm{DAA} + \mathrm{DDNA} \rightarrow \mathrm{DmRNA} + \mathrm{DtRNA}.$

can occur. If only DDNA-DNA and DmRNA-mRNA pairings occur this gives rise to transcription of DNA \rightarrow mRNA. Also reverse translation AA \rightarrow mRNA is possible.

2. One can consider also the reaction

 $DmRNA+DtRNA \rightarrow DAA + DmRNA$

is possible. If all pairings except DAA-AA pairing are present, the outcome is instead of translation the replication of mRNA such that the amino-acid in tRNA serves the role of catalyzer. I have considered the possibility that this process preceded the ordinary translation: in a phase transition increasing h_{eff} the roles of AA and RNA in tRNA would have changed [L92].

If this reaction is possible then also its reversal

 $\mathrm{DAA} + \mathrm{DmRNA} \rightarrow \mathrm{DmRNA} + \mathrm{DtRNA}$

is allowed. If all pairing except DmRNA-mRNA occur, this gives rise to AA +RNA \rightarrow tRNA allowing to generate tRNA from AA and RNA (not quite RNA).

3. The replication of DNA strand would correspond at dark level to a formation of bound states by the reaction

DDNA+DDNA \rightarrow DDNA $+_{bound}$ DDNA

in which all particles are paired. The opening of DNA double strand would correspond to the reverse of this bound state formation.

These dark particle reactions behind the shadow dynamics of life should be describable by S-matrices, which one might call the S-matrix of life.

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1. For instance for

 $DmRNA+DtRNA \rightarrow X$,

where X can be DmRNA+DtRNA (nothing happens - forward scattering) or DAA + DDNAand perhaps even DAA+DmRNA, one would have unitary S-matrix satisfying $SS^{dagger} = Id$ giving probability conservation as $\sum_{n} p_{m,n} = |S_{mn}|^2 = 1$ as a special case. Writing S = 1 + iT unitarity gives $i(T - T^{\dagger}) + TT^{dagger} = 0$ giving additional constraints besides probability conservation.

For

 $DmRNA+DtRNA \rightarrow DAA + DDNA$

the non-vanishing elements of T are only between pairs [(DmRNA,DtRNA), (DAA,DDNA)]for which mRNA pairs with tRNA and DNA codes for AA. Unitary matrix would be coded by amplitudes $t(AA, DNA_i(A))$ satisfying $\sum_i p_i(DAA) = p(DDNA + DAA), p_i(AA) =$ $|t(DAA, DDNA_i(A)|^2$. p(DDNA+DAA) equals to p(DDNA+DAA) = (1-p)Br(DDNA+DAA)DAA), where p is the probability that nothing happens (forward scattering) and Br(DDNA+DAA) is the branching ratio to DDNA+DAA channel smaller than 1 if Br(DDNA +DmRNA is non-vanishing. The natural interpretation for $p_i(AA)$ would be as probability that DNA_i codes for it.

2. For the reverse reaction

DAA + DDNA rightarrow DmRNA+DtRNA

it is natural to assume that DtRNA corresponds to any tRNA, which pairs with RNA. The AA associated with this tRNA is always the same but the counterpart of RNA can vary (wobbling). One can speak of the decomposition of dark genetic code to $DmRNA \rightarrow$ $DtRNA \rightarrow DAA$ to a pair of codes mapping DmRNA to DtNRA and DtRNA to DAA [L88]. There is a set $tRNA_i(mRNA)$ of tRNAs coding for given mRNA, and the probabilities $p_i(DmRNA)$ sum up to $p = \sum_i p_i(DmRNA) = (1-p)Br(DmRNA + DtRNA)$, where p is the probability for forward scattering and Br(DmRNA + DtRNA) is the branching fraction. The natural identification of $p_i(DmRNA)$ is as the probability that mRNA pairs with $tRNA_i$.

A possible weak point of the proposal is pairing: what are the conditions under which it occurs and are different pairing patterns possible. Possible second weak point is purely group theoretic: one should check whether which reactions are allowed by the tensor product decompositions for the states of dark proton triplets.

17.2.12Homeostasis

Homeostasis means that system is able to preserve its flow equilibrium under changing conditions. This involves many-layered hierarchies of pairs of control signals with opposite effects so that the system stays in equilibrium. For instance, we could not stand without this control system as one can easily check by using non-living test body! For instance, in bio-chemical homeostasis the ratios of concentrations remain constant. It is not at all clear whether ordinary chemistry can explain homeostasis.

In zero energy ontology (ZEO) one can imagine very fundamental mechanism of homeostasis.

1. Zero energy states are pairs of ordinary 3-D states with members located at opposite boundaries of causal diamond (CD). Their total quantum numbers are opposite, which is only a way to say that conservation laws hold true. The space-time surfaces connecting the 3-surfaces are preferred extremals of the action principle.

In quantum field theory this picture can be seen only as a book keeping trick and one assumes that space-time continues beyond causal diamond. There is however no need for this in TGD framework although it is natural to assume that there is some largest CD beyond which space-time surfaces do not continue. CDs form a hierarchy and sub-CDs of this CD can be connected by minimal surfaces, which are analogs of external particles. One obtains networks analogs to twistor Grassmannian diagrams.

2. Conscious entities (selves) correspond in ZEO to a sequences of state function reductions having interpretation as weak measurements, "small" state function reductions [L77]. In given weak measurement the members of the zero energy state at the passive boundary of CD are not affected: this is essentially Zeno effect associated with repeated measurements in ordinary quantum theory. The members of the state pairs at the active boundary of CD change and also the temporal distance between the tips of CD increases: this assigns a clock time to the experienced flow of time as sequence of state function reductions.

Eventually it becomes impossible to find observables, whose measurement would leave the passive parts of the zero energy state invariant. First "big" state function reduction changing the roles of active and passive boundaries of CD takes place and time begins to run in opposite direction since the formerly passive boundary recedes away from the formerly active boundary which is now stationary. Self dies and re-incarnates with an opposite arrow of time. In TGD biology these two time-reversed selves are proposed to correspond to motor actions and sensory perceptions.

Already Fantappie [J82] realized that two arrows of time seem to be present in living matter (consider only spontaneous assembly of bio-molecules as decay in opposite direction) and introduced the notion of syntropy as time-reversed entropy. For an observer with given arrow of time, a system with opposite arrow of time seems to break the second law. Temperature and concentrations gradients develop, system self-organizes.

3. These two quantal time evolutions with opposite arrows of time look very much like competing control signals in homeostasis. The 4-D conscious entities corresponding to control signals would have finite lifetime so that in their ensemble the effects of the signals with opposite arrows of time tend to compensate. This would give rise to homeostasis.

17.2.13 Evolution

I forgot perhaps the most important piece from the original text. Philosopher cannot avoid the question "What is evolution?"

In standard biology evolution is mystery. If one believes on standard thermodynamics, evolution is impossible by second law and the eventual heat death is unavoidable. Evolution means generation of structures and second law indeed states that all gradients die so that the finals state is totally uninteresting homogenous stuff.

I already mentioned the weird proposal that biology is just an enormous thermodynamical fluctuation. Boltzmann brain was indeed a kind of fad of pop physicists for some years ago. The idea - if you want to call it such - was that Boltzmann brains - and also ours - popped up from the multiverse by a complete accident. One could even argue that this occurred only at planet Earth to make the claim more plausible. This is however not science anymore, this is just pure plain idiocy.

Philosopher asks questions and now the most obvious questions are following. Is evolution something much more general than biological evolution? Is evolution a basic aspect of physics as already cosmological evolution suggests? Is evolution "must", something completely unavoidable? What could force it?

The Universe governed by second law certainly does not allow evolution: just the contrary. Could the increase of entropy and increase of conscious information and development of cognition relate somehow? It has been argued by Jeremy England [I114] (see http://tinyurl.com/o64rd7o) that biological evolution involves increase of the rate of entropy production as any-one can see by just looking around. These two things are not the same but are they somehow related [L37] (see http://tinyurl.com/zjp3bp6).

Philosopher gets now childishly excited. We must just tolerate. Our philosopher already mentioned that p-adic physics as physics of cognition not only leads to a measure for conscious information - something very non-trivial - but to adelic physics fusing physics in various number fields [L74, L75]. Adeles form a hierarchy labelled by the dimension of the extension of rationals inducing the extension of p-adic number fields labelled by primes. This dimension corresponds to the effective value of Planck constant and the larger it is, the larger the scale of quantum coherence is.

This has been already said but now comes the basic point and philosopher gets really excited. Since the number of extensions of rationals with dimension larger than given integer n is finite and the number of those with dimension larger than n is infinite, this dimension is bound to increase in statistical sense in the sequence of state function reductions recreating the quantum Universe again and again. Evolution is unavoidable! This is like random work from origin upwards. The height from the origin unavoidably increases.

Even more, the total negentropy coming from various p-adic sectors turns out to be larger than the entropy coming from the real sector. The bad news - not actually a news - is that increase of this negentropy is accompanied by the increase of entropy: civilizations indeed have the bad habit of polluting their environments. The good news is that negentropy increases faster than entropy: for a trivial extension of rationals from which everything would have started, negentropy equals to entropy. But for more complex extensions it is larger.

17.2.14 Darwinian or neutral theory of evolution or something else?

I learned recetly that the so called neutral theory of evolution has been challenged by evidence for DNA selection (see http://tinyurl.com/ybhyh6rc). I must admit that I had no idea what neutral theory of evolution means. I had thought that Darwinian view based on random mutations and selection of the most adaptive ones is the dominating view. The debate has been about whether Darwinian or neutral theory of evolution is correct or is some new vision needed. This inspired a more precise formulation of how evolution at genetic level could take place in TGD Universe.

Darwinian and neutral theories of evolution

Darwinian and neutral theories of evolution and their variants represent two different views about evolution.

1. Adaptive evolution is the Darwinian view. Random mutations are generated and organisms with the most adaptive genome survive. One can of course argue that also recombination occurring during mitosis creating germ cells creates new genetic combinations and must be important for the evolution. Selection can be either negative (purifying) and eliminate the non-adaptive ones or positive favoring the reproduction of the adaptive ones.

One can argue that notions like "fight for survival" and selection do not fit with the idea about organisms as basically inanimate matter having no goals. Also second law poses problems: no evolution should take place, just the opposite. Metabolic energy feed induces self-organization but by second law all gradients about which metabolic energy feed is an example, disappear.

2. Neutral evolution theory was proposed by Morita 50 years ago and gained a lot of support because of its simplicity. Point mutations for the codons of DNA would create alleles. Already in Darwinian evolution one knows that large fraction of mutations are neutral having not positive or negative effect of survival. Morita claims that all mutations are of this kind. There would be no "fight for survival" or selection.

The so called genetic drift, which is completely random process is possible in small populations and can lead to counterpart of selection: it can happen that only single allele remains and is counterpart for the winner in selection. This is purely random and combinatorial effect and in physics one would not call it drift.

The first objection is that if one has several isolated small populations, the outcomes are completely random so that in this sense there is no genetic drift. Furthermore, there is no reason why further mutations would not bring the disappeared alleles back. Second objection is that there would not be no genuine evolution - how one can speak about theory of evolution?

Now the feed of experimental and empirical data is huge as compared to what it was 5 decades ago and it is now known that the neutral theory fails: for instance, varying patterns of evolution among species with different population sizes cannot be understood. It is also clear that selection and adaptions really occur so that Darwin was right.

3. The shortcomings of the neutral theory led Ohta to propose nearly neutral theory of evolution. Mutations can be slightly deleterious. For large populations this leads to a purging of slightly deleterious mutations. For small populations deleterious mutations are effectively neutral and lead to the genetic drift.

There is however a further problem: why the rate of evolution varies as observed between different lineages of organisms.

4. One reason for fashionability was that the model was very simple and allowed to compute and predict. Only the size of the population and rate for the mutations is enough to predict the future in small populations. The predictions have been poor but this has not bothered the proponents of the neutral evolution theory.

As an outsider I see this as a typical example of a fashionable idea: these have plagued theoretical particle physics for four decades now and led to a practically complete stagnation of the field via hegemony formation. Simple arguments show that the idea cannot be correct but have no effect.

Article explains several related notions.

- 1. It has been possible to determine the mutation rates at the level of individual sites of genome since 2005. Only subset of mutations of say cancer cells are functionally important to cancer and they can be identified. This leads to a selection intensity as basic notion. This notion is expected to be very valuable for the attempts to find targeted cure of cancer.
- 2. Neutral theory of evolution assumes that only point mutations matter. Theory was therefore completely local at the level of genome - and certainly simple! Innocent outsider knowing a little bit about biology wonders why the recombination of maternal and paternal chromosomes in meiosis creating the chromosomes associated with germ cells are not regarded as important. This mechanism is non-local at the level of genome and would naturally lead to a selection at the level of individuals of the species. It has been indeed learned that the genetic variation and the rate of recombination in meiosis correlate in given region of genome. This sounds almost obvious to the innocent novice but had to be discovered experimentally.

One can however still try to keep the neutral theory of evolution by assuming that recombination is completely random process and there is no selection and adaption - contrary to the experimental facts and the basic idea behind the notion of evolution. Recombination would bring only an additional complication.

Besides the direct purifying selection and neutral drift there would be recombination creating differences in the levels of variation across the genomic landscape. This leads to the notion of genetic hitchiking. When beneficial alleles are closely linked to neighboring neutral mutations, selection acts as a unit on them. One speaks about linked selection. Frequencies of neutral alleles are determined by more than genetic drift but one can speak of neutrality still. Linkage of hitchiker to allele - beneficial or not - is however random. Does genuine evolution takes place at all?

- 3. Most of the DNA is not expressed as proteins. It would not be surprising if this part of DNA could have important indirect role in gene expression or perhaps be expressed in some other manner say electromagnetically. How important role this part of DNA has in evolution? There are also transposons inducing non-point like mutations of this part of DNA: what is their role. There also proposals that viruses, usually though to be a mere nuisance, could play decisive role in evolution by modifying the DNA of host cells.
- 4. It is now known that up to 80-85 per cent of human genome is probably affected by background selection. Moreover, height, skin color blood pressure are polygenic properties in the sense that hundreds or thousands of genes are acting in concert to determine these properties. This strongly suggests that point-like mutations cannot be responsible for evolution and not even recombinations are enough if random. A control of evolution in longer scales seems to be required. This of course relates to the basic problem of molecular biology: what gives rise to the coherence of living matter. Mere bio-chemistry cannot explain this. Something else perhaps controlling the bio-chemistry is needed.

TGD based view about evolution

One can start by criticizing the standard view.

- 1. Is the standard view (to the existent that such exists) about evolution consistent with second law? One can even ask whether standard view about thermodynamics assuming a fixed arrow of time is correct.
- 2. If mutations and more general changes of genome occur by pure change, can they really lead to a genuine evolution. The notions of selection and survival of fittest are notion, which do not conform with the view about evolution as mere standard physics. A probable motivation for neutral evolution theory has been the attempt to get rid of these notions: physicalism taken to extreme.
- 3. The reduction of life to bio-chemistry does not allow to understand the coherence of organisms.
- 4. One can also criticize the reduction of life to mere genetics.
 - (a) Genetic dogma does not tell much about morphogenesis.
 - (b) Is genetic determinism a realistic assumption? Clones of bacterium are know know to have personalities behaving differently under given conditions (see http://tinyurl. com/us7fxlh).
 - (c) Most of the genome of the higher organisms consists of DNA not transcribed to RNA still interpreted as junk by some biologists. What about introns? Could there exists other forms of gene expression - say electromagnetic.

TGD based view about evolution can be seen as a response to these criticisms but actually developed from a proposal for a unification for fundamental interactions and from the generalization of quantum measurement theory leading to a theory of consciousness and generalization of quantum theory itself.

1. TGD leads to a new view about space-time and classical fields. In particular, many-sheeted space-time and magnetic body bring in new element changing dramatically the views about biology.

The notion of Maxwellian fields is modified. Unlike in Maxwellian theory any system has field identity, field body, in particular magnetic body (MB) carrying dark matter n TGD sense and in well-define sense at higher evolutionary level as compared to ordinary bio-matter. This expands the standard pairing organism-environment to a triple MB-organism-environment.

MB can be seen as the controlling intentional agent and its evolution would induce also the evolution of the ordinary bio-matter. MB carries dark matter as $h_{eff}/h_0 = n$ phases giving rise to macroscopic quantum coherence at level of MB. MB forces the ordinary bio-matter to behave coherently (not quantum coherently).

TGD leads also to a realization of genetic code at the level of dark analog of DNA represented as dark proton sequences [L97] - dark nuclei, which are now essential element of TGD based view about nuclear physics [L110]. Dark photons are essential for the communications between MB and ordinary bio-matter. Also dark photons would realize genetic code with codon represented as 3-chord consisting of 3 dark photons.

Genetic modification would take place at the level of magnetic flux tubes containing dark analog of DNA and induce changes of the ordinary genome, which would do its best to mimic dark genome. In particular, the recombination occurring during the meiosis would be induced by the reconnection of the flux tubes of dark genome.

2. Number theoretical vision about evolution deriving from the proposal that p-adic physics for various primes combining to what I call adelic physics is second needed element [L75]. Any system can be characterized by a extension of rationals defining its algebraic complexity. The dimension of extension identifiable in terms of the effective Planck constant $h_{eff}/h_0 = n$ defines evolutionary level as a kind of IQ. What is remarkable that n increases in statistical sense since the number extensions with n larger than that for given extension is infinitely larger than that of lower-dimensional extensions. Intelligent ones have larger scale of quantum coherence and thus coherence of bio-matter and survive. Evolution is directed process forced by number theory alone.

Quantum jumps in the sense of ZEO tending to increase n occurring naturally in mitosis generating germ cells lead also to a more intelligent genomes. Point mutations could be seen something occurring at the level of ordinary matter rather than being induced by dark matter.

3. Zero energy ontology (ZEO) is behind the generalization of quantum measurement theory solving the basic problem of standard quantum measurement theory. There are two kinds of state function reductions. "Small" state function reductions (SSFRs) as analogs of weak measurements give rise to the life cycle of conscious entity self having so called causal diamond (CD) as a correlate. Under SSFRs the passive boundary of CD is unaffected as also members of state pairs at it: this gives rise to the "soul" as unchanging part of self.

"Big" state function reductions (BSFRs) correspond to ordinary state function reductions. They change the arrow of time and one can say that self dies and re-incarnates with a reversed arrow of time. This applies in all scales since consciousness and cognition predicted to be universal. In BSFRs the value of h_{eff} increases in statistical sense and this gives rise to evolution also at the level of genome. The reversal of the arrow of time allows to see self-organization and metabolism as dissipation in non-standard time direction so that generalization of thermodynamics to allow both arrows of time allows to understand both self-organization and evolution.

What could happen in meiosis and fertilization?

A possible application would be TGD based model for meiosis and fertilization.

- 1. In meiosis BSFR for the dark proton sequences defining dark DNA could induce reconnections of parallel maternal and paternal dark proton flux tubes inducing recombination at the level of the ordinary genome.
- 2. The resulting germ chromosomes or rather their dark variants realized in terms of dark proton sequences would have arrow of time opposite that of chromosomes. They would be in a dormant state analogous to sleep.
- 3. Fertilization involves the pairing of paternal and maternal germ chromosomes and looks almost like time reversal of meiosis. In the proposed picture it would indeed change the arrow of time for the germ chromosomes wake up them. The sequence meiosis replication-meiosisI-division meiosisII would correspond to 4 BSFRs leading to germ cells having dark genome as as time reversal of ordinary genome.

Remark: One can ask whether also the passive strand of ordinary DNA has arrow of time opposite to that of the active strand.

Mutations do not add: global epithasis and the notion of dark DNA

The Quanta Magazine article "How Genetic Surprises Complicate the Old Doctrine of DNA" (rebrand.ly/xhr95c4) provides a lot of food for thought. Epistasis is the concept discussed. One has a reasonable empirical understanding of point mutations. Point mutations are however not independent as simple linear thinking would suggest. This gives rise to epistasis.

Two mutations with qualitatively similar effects can produce a mutation with an opposite effect. Poorly understood interactions between mutations exist and give rise to the epistasis. One might call these interactions non-linear in a lack of a better word. The proposal that has been developed is global epistasis [I50] (rebrand.ly/9jkuylm) suggesting that genes and even large units would tend to have like coherent units.

My own intuitive view of DNA is based on quantum coherence in DNA length scales predicted by the TGD based view of chemical DNA as a chemical "shadow" of what I call dark DNA. Dark DNA is realized as sequences of dark protons at the monopole flux tubes of the magnetic body associated with the ordinary DNA. It relies on a universal realization of the genetic code based on a completely unique icosa-tetrahedral tessellation of hyperbolic 3-space (light-cone proper time constant 3-surface in Minkowski space M^4). Genetic code might be universal at the level of the magnetic body and biological realization(s!?) would be only of the many. This would make the Universe intelligent, conscious and evolving in all scales using the fundamental binary coded with a codon as a 6-qubit unit [L145].

Not only codons but also genes would be quantum coherent units interacting like particles. For instance, dark genes consisting of N dark codons (each with 3 dark protons) would emit 3Nphoton as a single unit in communications based on 3N-resonance, which implies that identical dark genes can communicate with each and that the modulation of frequency scale as a message is coded to a sequence of resonance peaks analogous to a sequence nerve pulses. This is a quantum generalization of what occurs in radio communications. Even larger quantum coherent units can be considered.

This implies that mutations are not anymore independent as in the picture based on chemistry alone. Mutations could have profound effects on the communications by 3N-resonance and 3N frequency resonance is not anymore complete if one codon changes. Therefore the effects of two or more mutations on dark gene communications do not simply add up. This raises the hope that their interactions might be understood some day.

Phenotype is much more stable against point mutations of genotype as one might expect: Why?

Paul Kirsch sent an interesting link (rebrand.ly/r7pdwdj) to a genetics related article [I69] discussing the question how stably genotype determines the phenotype. The article proposed a number theoretic formula for the probability that a point mutation does not affect the phenotype. This probability is called robustness of the phenotype. The number theory involved is very different from that in the TGD framework and I do not understand the technical details.

One considers the correspondence between genotype and phenotype and point mutations in which code letter changes. The point mutations that do not affect the phenotype, are called neutral.

- 1. It is empirically found that robustness defined as the probability that a point mutation does not change a phenotype is orders of magnitudes higher than expected by assuming that this property is given by the probability that a random letter sequence gives rise to the phenotype. This is very natural since it makes possible steady evolution: quite few point mutations change the phenotype. This requires that there are strong correlations between genes which can give rise to a given phenotype. The pool of allowed letter sequences is much smaller than the pool of all possible letter sequences.
- 2. It is argued that a certain number theoretical function gives a good estimate for this probability. I have no idea how they end up with this proposal. What this also suggests to me is that quite generally, the allowed genes are not random sequences of letters. There are correlations between them.

Could one understand these correlations by using the number theoretic view of biology proposed in the TGD framework? Consider first how general quantum states are constructed in number theoretical vision.

- 1. In the TGD framework, all quantum states are regarded as Galois singlets formed from dark particles. This universal mechanism for the formation of bound states is a number theoretic generalization of the notion of color confinement.
- 2. One obtains a hierarchy of Galois confined states. If one has Galois singlets at a given level one can deform them to non-singlets. One can also consider a larger extension in which the Galois group is larger and singlets cease to be singlets. One can however form Galois singlets of them at the next level. This is the general picture and applies to any physical state in number theoretical vision. In biology dark codons, dark genes, parts of the genome, perhaps even the genome, can belong to this hierarchy.

3. What does Galois singletness mean? The momentum components assignable to the Galois singlet as a bound state are Galois singlets and therefore ordinary integers when the momentum unit defined by causal diamond is used. The momenta of the particles forming the Galois singlet state are not Galois singlets: they have momentum components which are algebraic integers which can be complex. They are analogous to virtual particles. Galois singletness gives a large number of constraints: their number is 4 times (d-1), where d is the dimension of the extension.

This mechanism for the formation of bound states is universal and should apply also to codons and genes.

- 1. Free dark codons would be Galois singlets formed from 3 dark protons, which are not Galois singles. In gene, dark codons need not be Galois singlets anymore but the gene itself must be a Galois singlet and therefore defines a quantum coherent state analogous to hadron and behaving like a single unit in its interactions.
- 2. Galois singletness poses a constraint on the gene as a quantum state. Not any combination of dark codons is possible as a dark gene. In the momentum representation, the total momentum of genes as a many-codon state must have components, which are ordinary integers in the unit defined by the causal diamond. The momentum components assignable to codons are algebraic integers: they are analogous to virtual particles.

17.2.15 Maximally symmetric Universe, self-organized quantum criticality, and symmetry between order and disorder

The following comments were inspired by the Big Think article "A surprise new theory of everything involves the symmetry between order and disorder" (https://rb.gy/vyh8g). The article relates to the book "The language of symmetry" edited by Rattigan, Noble and Hatta (https://rb.gy/h0d7n).

Two ideas considered in the article, maximal symmetries and self-organized criticality, define two key principles of TGD. Also the third, rather paradoxical idea that symmetry breaking leads to a generation of symmetry, has a precise meaning in the TGD Universe.

Consider first the maximization of symmetries as a fundamental principle.

1. In the TGD framework, the fundamental principle determining physics as geometry is that the infinite-dimensional geometry of the "world of classical worlds" (WCW) exists mathematically. Physics is unique because of its mathematical existence and has maximal symmetries.

Freed demonstrated that for the loop spaces this geometry is unique and indeed has an infinite-D group of isometries (Kac-Moody symmetries).

- 2. 4-D general coordinate invariance is essential in TGD and implies holography in reducing to a generalization of 2-D holomorphy to 4-D case, which in turn corresponds to 4-D quantum criticality.
 - (a) The first guess would be that WCW consists of 3-D surfaces in $H = M_2^4$: $H = M_2^4$ is indeed unique by several mathematical arguments and also by standard model symmetries. 3-surface generalizes the notion of a point-like particle.
 - (b) 4-D general coordinate invariance requires that a given 3-surface corresponds to a *nearly* unique 4-surface in *H*. This means holography, or equivalently, Bohr orbitology. WCW also has interpretation as a space of 4-D analogs of Bohr orbits. Quantum TGD becomes the analogue of wave mechanics in WCW.

Note that in atomic physics this would mean the replacement of electrons configuration space E^3 with the space of its Bohr orbits: this would be fiber space over E^3 with fiber at given point consisting of Bohr orbits through it.

Consider next self-organized criticality as a basic principle. In TGD quantum criticality is behind the analogous principle.

1. For 2-D systems conformal invariance implying holomorphy of string orbits extends to 4-D analog of holomorphy, which realizes quantum criticality in 4-D case. Holomorphy implies holography!

Field equations reduce to a purely algebraic form, having no dependence on the coupling parameters of the action as long as it is general coordinate invariant and constructible using the induced geometry.

2. This happens outside 3-D and lower-D singularities. Space-time surface is a minimal surface, analog of a soap film spanned by frames. Minimal surface property is analog of massless field equations at field level and analog of massless geodesic property at particle level. The classical and quantum dynamics distinguishes between different actions only at the frames, which can however depend on action.

To understand the self-organized quantum criticality (SOC), quantum TGD is required.

- 1. In Quantum TGD, wave functions of the ordinary wave mechanics are replaced with analogs of wave functions in WCW (WCW spinor fields as many-fermion states as WCW spinors) consisting of analogs of Bohr orbits. This forces a new ontology: I call it zero energy ontology (ZEO) forcing a new view of quantum measurement.
- 2. In state function reduction (SFR) this kind of superposition inside quantization volume (causal diamond (CD) is replaced with a new one, and also the size and other parameters characterizing the CD can change. The standard paradox of quantum measurement theory disappears.
- 3. There are two kinds of SFRs.
 - (a) In small SFRs (SSFRs), the boundary of CD is stationary and states at it are not affected but the active boundary is shifted and CD tends to increase. The sequences of SSFRs correspond to Zeno effect, having no effect in standard QM, and give rise to a conscious entity, self, for which subjective time as sequence of SSFRs correlates with the increase of the distance between tips of CD.
 - (b) In big SFRs (BSFRs), the arrow of time changes so that the active boundary of the CD [L155] becomes passive and vice versa. BSFRS correspond to ordinary SFRs. BSFR means "death" of self and reincarnation with an opposite arrow of time. Even small perturbations can induce BSFR by affecting the set of the observables measured in SSFR: if the new set does not commute with those defining the passive states, BSFR unavoidably occurs.
 - (c) BSFRs give rise to SOC. Self lives at criticality against death! This is the analogy for the critical sandpile. As a consequence, the flow of consciousness of self has gaps with a distribution of gap durations. This is known for human consciousness [L159].
- 4. Paradoxically, this continual short term dying in BSFRs makes it possible for the system able to survive and correct behaviors. Self can also learn of avoidable behaviors by trial and error. Self can learn moral and ethical rules: do not do anything destroying quantum coherence! [L151]. Perhaps most of the learning is by this method.

Homeostasis is a basic implication [L164]. The system is at quantum criticality at the top of a hill and unstable. When it starts to fall down, it makes BSFR in some scale and changes the arrow of time and returns back near criticality. Self-organization, say spontaneous generation of molecules from their building bricks, can be understood as a time reversed dissipation.

The third topic discussed in the article relates to the paradoxical creation of symmetries by symmetry breaking. The emerging vision indeed is that symmetry breaking paradoxically leads to the emergence of a deeper symmetry. This is what the TGD view of the concrete realization of the isometries of WCW as symmetries of the physical system indeed predicts.

1. The half Virasoro algebra V with non-negative conformal weights serves as a simplified example. V contains an infinite set of sub-algebras V_k for which conformal weights are divisible by integer k = 1, 2, ... One also obtains inclusion hierarchies $...V_{k(n)}V_{k(n+1)}...$ such that k(n) divides k(n+1), whose generalizations are very relevant to quantum TGD.

2. The ordinary realization of conformal symmetries is as a gauge symmetry for which the generators L_n , n > 0, annihilate the physical states. One can however generalize this and only assume that V_k and $[V_k, V]$ for some k annihilate the physical states. In this case, the generators L_n , n < k do not annihilate the states and act as genuine symmetries. Gauge symmetries are broken but have transformed to genuine physical symmetries! This removes the paradox from the idea of emergence of symmetries by symmetry breaking!

These kinds of mathematical structures are the cornerstone of quantum TGD. Virasoro algebra is replaced with the isometry algebra of WCW and associated algebra but completely analogous conditions hold true. This mechanism would not hold true for the isometry algebra of WCW only.

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 regarded 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 adele [L74, L75]. In the recent view of quantum TGD [L143], both notions reduce to physics as number theory vision, which relies on $M^8 - H$ duality [L119, L120] and is complementary to the physics as geometry vision.

Zero energy ontology (ZEO) [L112] [K148] 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) [L112, L131] [K148] 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 [A27] 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

$$(z^1, z^2, z^3) \equiv \lambda(z^1, z^2, z^3) \quad . \tag{A-2.1}$$

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 homoeomorphic 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 [A20] will be used and their relation to the complex coordinates is given by

$$\xi^1 = z + it$$
,
 $\xi^2 = x + iy$. (A-2.2)

These are related to the "spherical coordinates" via the equations

$$\xi^{1} = rexp(i\frac{(\Psi + \Phi)}{2})cos(\frac{\Theta}{2}) ,$$

$$\xi^{2} = rexp(i\frac{(\Psi - \Phi)}{2})sin(\frac{\Theta}{2}) .$$
(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 Euler number 3, Pontryagin number 3 and second b = 1.

Fig. 4. CP₂ 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 $z^i \to exp(i\alpha)z^i$ 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

$$ds^2 = g_{a\bar{b}}d\xi^a d\bar{\xi}^b , \qquad (A-2.4)$$

where the Hermitian, in fact Kähler metric $g_{a\bar{b}}$ is defined by

$$g_{a\bar{b}} = R^2 \partial_a \partial_{\bar{b}} K \quad (A-2.5)$$

where the function K, Kähler function, is defined as

$$K = log(F) ,$$

$$F = 1 + r^2 .$$
(A-2.6)

The Kähler function for S^2 has the same form. It gives the S^2 metric $dz d\overline{z}/(1+r^2)^2$ 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

$$\frac{ds^2}{R^2} = \frac{(dr^2 + r^2\sigma_3^2)}{F^2} + \frac{r^2(\sigma_1^2 + \sigma_2^2)}{F} , \qquad (A-2.7)$$

where the quantities σ_i are defined as

$$r^{2}\sigma_{1} = Im(\xi^{1}d\xi^{2} - \xi^{2}d\xi^{1}) ,$$

$$r^{2}\sigma_{2} = -Re(\xi^{1}d\xi^{2} - \xi^{2}d\xi^{1}) ,$$

$$r^{2}\sigma_{3} = -Im(\xi^{1}d\bar{\xi}^{1} + \xi^{2}d\bar{\xi}^{2}) .$$
(A-2.8)

R denotes the radius of the geodesic circle of CP_2 . The vierbein forms, which satisfy the defining relation

$$s_{kl} = R^2 \sum_A e_k^A e_l^A , \qquad (A-2.9)$$

are given by

$$e^{0} = \frac{dr}{F} , \quad e^{1} = \frac{r\sigma_{1}}{\sqrt{F}} ,
 e^{2} = \frac{r\sigma_{2}}{\sqrt{F}} , \quad e^{3} = \frac{r\sigma_{3}}{r\sigma_{3}} .$$
(A-2.10)

The explicit representations of vierbein vectors are given by

$$e^{0} = \frac{dr}{F}, \qquad e^{1} = \frac{r(\sin\Theta\cos\Psi d\Phi + \sin\Psi d\Theta)}{2\sqrt{F}},$$

$$e^{2} = \frac{r(\sin\Theta\sin\Psi d\Phi - \cos\Psi d\Theta)}{2\sqrt{F}}, \quad e^{3} = \frac{r(d\Psi + \cos\Theta d\Phi)}{2F}.$$
(A-2.11)

The explicit representation of the line element is given by the expression

$$ds^{2}/R^{2} = \frac{dr^{2}}{F^{2}} + \frac{r^{2}}{4F^{2}}(d\Psi + \cos\Theta d\Phi)^{2} + \frac{r^{2}}{4F}(d\Theta^{2} + \sin^{2}\Theta d\Phi^{2}) .$$
(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

$$de^A = -V^A_B \wedge e^B , \qquad (A-2.13)$$

is given by

$$\begin{aligned}
 V_{01} &= -\frac{e^1}{r} , & V_{23} &= \frac{e^1}{r_2} , \\
 V_{02} &= -\frac{e^2}{r} , & V_{31} &= \frac{e^2}{r} , \\
 V_{03} &= (r - \frac{1}{r})e^3 , & V_{12} &= (2r + \frac{1}{r})e^3 .
 \end{aligned}$$
(A-2.14)

The representation of the covariantly constant curvature tensor is given by

$$\begin{array}{rcl}
R_{01} &=& e^{0} \wedge e^{1} - e^{2} \wedge e^{3} &, & R_{23} &=& e^{0} \wedge e^{1} - e^{2} \wedge e^{3} &, \\
R_{02} &=& e^{0} \wedge e^{2} - e^{3} \wedge e^{1} &, & R_{31} &=& -e^{0} \wedge e^{2} + e^{3} \wedge e^{1} &, \\
R_{03} &=& 4e^{0} \wedge e^{3} + 2e^{1} \wedge e^{2} &, & R_{12} &=& 2e^{0} \wedge e^{3} + 4e^{1} \wedge e^{2} &. \\
\end{array} \tag{A-2.15}$$

Metric defines a real, covariantly constant, and therefore closed 2-form J

$$J = -is_{a\bar{b}}d\xi^a d\bar{\xi}^b , \qquad (A-2.16)$$

the so called Kähler form. Kähler form J defines in \mathbb{CP}_2 a symplectic structure because it satisfies the condition

$$J_{r}^{k}J^{rl} = -s^{kl} {.} {(A-2.17)}$$

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

$$J = dB , \qquad (A-2.18)$$

where B is the so called Kähler potential, which is not defined globally since J describes homological magnetic monopole.

dJ = ddB = 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

$$B = 2re^{3} ,$$

$$J = 2(e^{0} \wedge e^{3} + e^{1} \wedge e^{2}) = \frac{r}{F^{2}}dr \wedge (d\Psi + \cos\Theta d\Phi) + \frac{r^{2}}{2F}\sin\Theta d\Theta \wedge d\Phi .$$
(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

$$B = \sum_{k=1,2} P_k dQ_k ,$$

$$J = \sum_{k=1,2} dP_k \wedge dQ_k .$$
(A-2.20)

The relationship of the canonical coordinates to the "spherical" coordinates is given by the equations

$$P_{1} = -\frac{1}{1+r^{2}},$$

$$P_{2} = -\frac{r^{2}cos\Theta}{2(1+r^{2})},$$

$$Q_{1} = \Psi,$$

$$Q_{2} = \Phi.$$
(A-2.21)

Spinors In CP₂

 CP_2 doesn't allow spinor structure in the conventional sense [A15]. 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 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 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 [A40] 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

$$[X, [Y, Z]] \in t \text{ for } X, Y, Z \in t . \tag{A-2.22}$$

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

$$\begin{split} S_I^2 &: \ \xi^1 = \bar{\xi}^2 \ \text{or equivalently} \ (\Theta = \pi/2, \Psi = 0) \ , \\ S_{II}^2 &: \ \xi^1 = \xi^2 \ \text{or equivalently} \ (\Theta = \pi/2, \Phi = 0) \ . \end{split}$$

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 [B23] 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

$$\Gamma \Psi = e \Psi ,$$

$$e = \pm 1 ,
 (A-2.23)$$

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

$$A = V + \frac{B}{2}(n_{+}1_{+} + n_{-}1_{-}) . \qquad (A-2.24)$$

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

$$\begin{aligned}
 V_{01} &= -\frac{e^1}{r} , & V_{23} &= \frac{e^1}{r} , \\
 V_{02} &= -\frac{e^2}{r} , & V_{31} &= \frac{e^2}{r} , \\
 V_{03} &= (r - \frac{1}{r})e^3 , & V_{12} &= (2r + \frac{1}{r})e^3 ,
 \end{aligned}$$
(A-2.25)

and

$$B = 2re^3 , \qquad (A-2.26)$$

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

$$A_{ch} = 2V_{23}I_L^1 + 2V_{13}I_L^2 , \qquad (A-2.27)$$

where one have defined

$$I_L^1 = \frac{(\Sigma_{01} - \Sigma_{23})}{2} ,$$

$$I_L^2 = \frac{(\Sigma_{02} - \Sigma_{13})}{2} .$$
(A-2.28)

 A_{ch} is clearly left handed so that one can perform the identification of the gauge potential as

$$W^{\pm} = \frac{2(e^1 \pm ie^2)}{r} , \qquad (A-2.29)$$

where W^{\pm} denotes the charged intermediate vector boson.

The covariantly constant curvature tensor is given by

$$R_{01} = -R_{23} = e^{0} \wedge e^{1} - e^{2} \wedge e^{3} ,$$

$$R_{02} = -R_{31} = e^{0} \wedge e^{2} - e^{3} \wedge e^{1} ,$$

$$R_{03} = 4e^{0} \wedge e^{3} + 2e^{1} \wedge e^{2} ,$$

$$R_{12} = 2e^{0} \wedge e^{3} + 4e^{1} \wedge e^{2} .$$
(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.

$$W_{03} = W_{12} \equiv 2I_3 = 2(e^0 \wedge e^3 + e^1 \wedge e^2) ,$$

$$W_{01} = W_{23} \equiv I_1 = -e^0 \wedge e^1 - e^2 \wedge e^3 ,$$

$$W_{02} = W_{31} \equiv I_2 = -e^0 \wedge e^2 - e^3 \wedge e^1 .$$

(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

$$X = re^{3} ,$$

$$Y = \frac{e^{3}}{r} ,$$
(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

$$\bar{\gamma} = aX + bY ,$$

$$\bar{Z}^0 = cX + dY ,$$
(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

$$A_{nc} = [(c+d)2\Sigma_{03} + (2d-c)2\Sigma_{12} + d(n_{+}1_{+} + n_{-}1_{-})]\bar{\gamma} + [(a-b)2\Sigma_{03} + (a-2b)2\Sigma_{12} - b(n_{+}1_{+} + n_{-}1_{-})]\bar{Z}^{0} .$$
(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

$$c = -d . (A-2.35)$$

Using this result plus previous equations, one obtains for the neutral part of the connection the expression

$$A_{nc} = \gamma Q_{em} + Z^0 (I_L^3 - \sin^2 \theta_W Q_{em}) .$$
 (A-2.36)

Here the electromagnetic charge Q_{em} and the weak isospin are defined by

$$Q_{em} = \Sigma^{12} + \frac{(n_{+}1_{+} + n_{-}1_{-})}{6} ,$$

$$I_{L}^{3} = \frac{(\Sigma^{12} - \Sigma^{03})}{2} .$$
(A-2.37)

The fields γ and Z^0 are defined via the relations

$$\gamma = 6d\bar{\gamma} = \frac{6}{(a+b)}(aX+bY) ,$$

$$Z^{0} = 4(a+b)\bar{Z}^{0} = 4(X-Y) .$$
(A-2.38)

The value of the Weinberg angle is given by

$$\sin^2 \theta_W = \frac{3b}{2(a+b)} , \qquad (A-2.39)$$

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

$$F_{nc} = 2R_{03}\Sigma^{03} + 2R_{12}\Sigma^{12} + J(n_+1_+ + n_-1_-) , \qquad (A-2.40)$$

where one has

$$R_{03} = 2(2e^{0} \wedge e^{3} + e^{1} \wedge e^{2}) ,$$

$$R_{12} = 2(e^{0} \wedge e^{3} + 2e^{1} \wedge e^{2}) ,$$

$$J = 2(e^{0} \wedge e^{3} + e^{1} \wedge e^{2}) ,$$
(A-2.41)

in terms of the fields γ and Z^0 (photon and Z- boson)

$$F_{nc} = \gamma Q_{em} + Z^0 (I_L^3 - \sin^2 \theta_W Q_{em}) . \qquad (A-2.42)$$

Evaluating the expressions above, one obtains for γ and Z^0 the expressions

$$\gamma = 3J - \sin^2 \theta_W R_{12} ,
Z^0 = 2R_{03} .$$
(A-2.43)

For the Kähler field one obtains

$$J = \frac{1}{3}(\gamma + \sin^2\theta_W Z^0) .$$
 (A-2.44)

Expressing the neutral part of the symmetry broken YM action

$$L_{ew} = L_{sym} + f J^{\alpha\beta} J_{\alpha\beta} ,$$

$$L_{sym} = \frac{1}{4g^2} Tr(F^{\alpha\beta} F_{\alpha\beta}) , \qquad (A-2.45)$$

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

$$X = -\frac{K}{2g^2} + \frac{fp}{18} ,$$

$$K = Tr \left[Q_{em} (I_L^3 - sin^2 \theta_W Q_{em}) \right] ,$$
(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

$$K = \sum_{i} \left[-\frac{(18+2n_{i}^{2})sin^{2}\theta_{W}}{9} \right] , \qquad (A-2.47)$$

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

$$\sin^2 \theta_W = \frac{9\sum_i 1}{(fg^2 + 2\sum_i (18 + n_i^2))}$$
 (A-2.48)

In the scenario where both leptons and quarks are elementary fermions the value of the Weinberg angle is given by

$$\sin^2 \theta_W = \frac{9}{\left(\frac{fg^2}{2} + 28\right)} . \tag{A-2.49}$$

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 [B5]. 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 $f \to 0$ 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 $f/g^2 \to 0$. 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.

- 1. 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).
- 2. 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.
- 3. $\langle Z^0 \rangle$ 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.

1. The electromagnetic field [L156] 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

$$R_{03} = 2(2e^{0} \wedge e^{3} + e^{1} \wedge e^{2}) = J + 2e^{0} \wedge e^{3} ,$$

$$J = 2(e^{0} \wedge e^{3} + e^{1} \wedge e^{2}) ,$$

$$R_{12} = 2(e^{0} \wedge e^{3} + 2e^{1} \wedge e^{2}) = 3J - 2e^{0} \wedge e^{3} ,$$

(A-2.50)

2. The induced fields γ and Z^0 (photon and Z- boson) can be expressed as

$$\gamma = 3J - \sin^2 \theta_W R_{12} ,$$

$$Z^0 = 2R_{03} = 2(J + 2e^0 \wedge e^3)$$
(A-2.51)
per. (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

$$\langle \gamma \rangle = (3 - 4sin^2 \theta_W) J$$
.

For $sin^2\theta_W = 3/4 \ langle\gamma$ would vanish.

The quantum averages of classical weak fields quite generally vanish. What about correlation functions?

1. 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. 2. 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.

3. 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:

- 1. Symmetries must be realized as purely geometric transformations.
- 2. 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

$$\Psi \quad \to \quad P\Psi = \gamma^0 \otimes \gamma^0 \Psi \quad . \tag{A-2.53}$$

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

$$\begin{array}{lll} m^k & \to & T(M^k) \ , \\ \xi^k & \to & \bar{\xi}^k \ , \\ \Psi & \to & \gamma^1 \gamma^3 \otimes 1\Psi \ . \end{array}$$
 (A-2.54)

The operation bearing closest resemblance to the ordinary charge conjugation corresponds geometrically to complex conjugation in CP_2 :

$$\begin{aligned} \xi^k &\to \quad \bar{\xi}^k \ , \\ \Psi &\to \quad \Psi^{\dagger} \gamma^2 \gamma^0 \otimes 1 \ . \end{aligned} \tag{A-2.55}$$

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 if 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 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 CP₂ projection, only vacuum extremals and space-time surfaces for which CP₂ 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

$$\gamma = (\frac{3}{4} - \frac{\sin^2(\theta_W)}{2})Z^0 \simeq \frac{5Z^0}{8}$$

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 CP₂ 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 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 then 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 that 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 generi 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.

- 1. 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.
- 2. 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 or 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.

- 1. 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.
- 2. 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.

- 3. 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.
- 4. 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.
- 5. 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

$$J = \frac{r}{F^2} dr \wedge (d\Psi + \cos(\Theta)d\Phi) + \frac{r^2}{2F} \sin(\Theta)d\Theta \wedge d\Phi ,$$

$$F = 1 + r^2 .$$
(A-3.1)

The general expression of electromagnetic field reads as

$$F_{em} = (3+2p)\frac{r}{F^2}dr \wedge (d\Psi + \cos(\Theta)d\Phi) + (3+p)\frac{r^2}{2F}\sin(\Theta)d\Theta \wedge d\Phi ,$$

$$p = \sin^2(\Theta_W) , \qquad (A-3.2)$$

where Θ_W denotes Weinberg angle.

1. The vanishing of the electromagnetic fields is guaranteed, when the conditions

$$\Psi = k\Phi ,$$

(3+2p) $\frac{1}{r^2F}(d(r^2)/d\Theta)(k+\cos(\Theta)) + (3+p)\sin(\Theta) = 0 ,$ (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

$$r = \sqrt{\frac{X}{1-X}} ,$$

$$X = D \left[\left| \frac{k+u}{C} \right| \right]^{\epsilon} ,$$

$$u \equiv \cos(\Theta) , \ C = k + \cos(\Theta_0) , \ D = \frac{r_0^2}{1+r_0^2} , \ \epsilon = \frac{3+p}{3+2p} ,$$
(A-3.4)

where C and D are integration constants. $0 \le X \le 1$ is required by the reality of r. r = 0would correspond to X = 0 giving u = -k achieved only for $|k| \le 1$ and $r = \infty$ to X = 1giving $|u + k| = [(1 + r_0^2)/r_0^2)]^{(3+2p)/(3+p)}$ achieved only for

$$sign(u+k) \times [\frac{1+r_0^2}{r_0^2}]^{\frac{3+2p}{3+p}} \le k+1$$
 ,

where sign(x) denotes the sign of x.

The expressions for Kähler form and Z^0 field are given by

$$J = -\frac{p}{3+2p} X du \wedge d\Phi ,$$

$$Z^{0} = -\frac{6}{p} J . \qquad (A-3.5)$$

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.

- 2. 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.
- 3. The vanishing Kähler field corresponds to $\epsilon = 1, p = 0$ in the formula for em neutral spacetimes. In this case classical em and Z^0 fields are proportional to each other:

$$Z^{0} = 2e^{0} \wedge e^{3} = \frac{r}{F^{2}}(k+u)\frac{\partial r}{\partial u}du \wedge d\Phi = (k+u)du \wedge d\Phi ,$$

$$r = \sqrt{\frac{X}{1-X}} , \quad X = D|k+u| ,$$

$$\gamma = -\frac{p}{2}Z^{0} .$$
(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

$$\begin{aligned} ds_{eff}^2 &= (s_{rr}(\frac{dr}{d\Theta})^2 + s_{\Theta\Theta})d\Theta^2 + (s_{\Phi\Phi} + 2ks_{\Phi\Psi})d\Phi^2 = \frac{R^2}{4}[s_{\Theta\Theta}^{eff}d\Theta^2 + s_{\Phi\Phi}^{eff}d\Phi^2] , \\ s_{\Theta\Theta}^{eff} &= X \times \left[\frac{\epsilon^2(1-u^2)}{(k+u)^2} \times \frac{1}{1-X} + 1 - X\right] , \\ s_{\Phi\Phi}^{eff} &= X \times \left[(1-X)(k+u)^2 + 1 - u^2\right] , \end{aligned}$$
(A-3.7)

and is useful in the construction of vacuum embedding of, say Schwartchild 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

$$\Psi = \omega_2 m^0 + k_2 m^3 + n_2 \phi + \text{Fourier expansion} ,$$

$$\Phi = \omega_1 m^0 + k_1 m^3 + n_1 \phi + \text{Fourier expansion} .$$
(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

$$\Omega \equiv \frac{\omega_2}{n_2} - \frac{\omega_1}{n_1} = 0 \quad , \tag{A-3.9}$$

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 4surfaces and this leads to zero energy ontology (ZEO) in which quantum states are superpositions of space-time surfaces [K65, K39, K109] [L132, L143].

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 4dimensional 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 induces 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.

- 1. 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.
- 2. 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.

- 1. 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 superconformal 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.
- 2. 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.
- 3. 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 spacetime 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 [K65, K109].

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 [L76] [L132, L134, L135] 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 [A27] 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.

- 1. 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.
- 2. 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.
- 3. 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.

- 1. 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.
- 2. 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.

- 1. 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.
- 2. 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 actings 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 [L143]. There are also other important algebras but these will not be discussed now.

1. 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 [L143] 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.

2. 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 [L143] 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).

- 1. 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.
- 2. This coupling constant evolution could naturally correspond to that assignable to the inclusion hierarchy of hyperfinite factors of type II₁ (HFFs). I have indeed proposed [L143] 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).
- 3. The actions related to different values of n(P) = n(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.

4. 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 II₁.

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 [L137] 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.

5. 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 [K81, K82]). 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).

1. Ramified primes are factors of the discriminant D(P) of P, which is expressible as a product of non-vanishing root differents 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 [L137], 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).

2. According to [L137], 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 [L137].

3. p-Adic length scale hypothesis [L144] 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.

1. 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 [L143] 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.

2. The symplectic transformations of WCW acting as isometries are assumed to be induced by the symplectic transformations of $\delta M_+^4 \times CP_2$ [K65, K39]. 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 [L141].

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 [K86, K74, K36]. The fusion of the various p-adic physics leads to what I call adelic physics [L74, L75]. Later the hypothesis about hierarchy of Planck constants labelling phases of ordinary matter behaving like dark matter emerged [K41, K42, K43, K43].

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 [L119, L120] 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 [L137, L141]. 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 [L76] 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 [A12]. p-Adic numbers are representable as power expansion of the prime number p of form

$$x = \sum_{k \ge k_0} x(k)p^k, \ x(k) = 0, \dots, p-1 \ . \tag{A-6.1}$$

The norm of a p-adic number is given by

$$|x| = p^{-k_0(x)} (A-6.2)$$

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

$$x = p^{k_0} \varepsilon(x) , \qquad (A-6.3)$$

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:

$$d(x,z) \leq max\{d(x,y), d(y,z)\} .$$
 (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

$$d(x,y) \leq D . \tag{A-6.5}$$

This division of the metric space into classes has following properties:

- 1. 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.
- 2. Distances of points x and y inside single class are smaller than distances between different classes.
- 3. 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 [B17]. 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 $I: R_p \to R_+$ 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

$$y = \sum_{k>N} y_k p^k \to x = \sum_{k
$$y_k \in \{0, 1, .., p-1\} .$$
(A-6.6)$$

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...) for the real numbers x, which allow pinary expansion with finite number of pinary digits

$$x = \sum_{k=N_0}^{N} x_k p^{-k} ,$$

$$x = \sum_{k=N_0}^{N-1} x_k p^{-k} + (x_N - 1) p^{-N} + (p - 1) p^{-N-1} \sum_{k=0,..} p^{-k} .$$
(A-6.7)

The p-adic images associated with these expansions are different

$$y_{1} = \sum_{k=N_{0}}^{N} x_{k} p^{k} ,$$

$$y_{2} = \sum_{k=N_{0}}^{N-1} x_{k} p^{k} + (x_{N} - 1) p^{N} + (p - 1) p^{N+1} \sum_{k=0,..} p^{k}$$

$$= y_{1} + (x_{N} - 1) p^{N} - p^{N+1} ,$$
(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:

$$(x+y)_R \leq x_R + y_R ,$$

 $|x|_p |y|_R \leq (xy)_R \leq x_R y_R ,$ (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).

$$(x+y)_R \leq x_R + y_R ,$$

$$|\lambda|_p |y|_R \leq (\lambda y)_R \leq \lambda_R y_R , \qquad (A-6.10)$$

where the norm of the vector $x \in T_p^n$ is defined in some manner. The case of Euclidian space suggests the definition

$$(x_R)^2 = (\sum_n x_n^2)_R . (A-6.11)$$

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

$$I_Q(q = p^k \times \frac{r}{s}) = p^k \times \frac{I(r)}{I(s)}$$
(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 $0 \le r < p$ and $0 \le s < p$. 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 \mathbb{R}^n must be covered by 2^n copies of the p-adic variant \mathbb{R}^n_p of \mathbb{R}^n each of which projects to a copy of \mathbb{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 $e^p \mod p = 1$. 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.

- 1. 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
- 2. 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
- 3. Canonical identification violates general coordinate invariance of chart map: (cognitioninduced 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 migh be understood as Bohr orbits for a gigantic gravitational Planck constant.

Hierachy 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-determism 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 agiven 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 lightlikeness property of partonic orbits at which the signature of the induced metric changes from Minkowskian to Euclidian (Minkowskianb 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 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 4.6.6) has changed considerably towards the end 2021 [L132] 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 [L132] 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 [L132] 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 $X^4 \subset M_c^8$ (M^8 is complexified to M_c^8) as a "root" of its octonionic continuation [L119, L120]. 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 $X^4 \subset M^8$ [L103]. 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 [L132]. 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 [L124] 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 [L132]. 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 [L112] [K148].

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. 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 [L112].

- 2. To avoid getting totally confused 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 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.
- 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 [L98] in atomic scale can be explained by the same mechanism [L98]. 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 [J15] 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.
- (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 [L101]. 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 [L107, L164].

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 [L107, L164]. 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.

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 fromt 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 communicated 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/reconect2.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 padjusted adjusted adju

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 padic manifold can be interpreted as formation of though, 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 intentational 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

Acknowledgements: I am grateful for Dainis Zeps for enlightnening discussions concerning CP_2 geometry.

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